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JOURNAL

VOLUME 13, NUMBER 10 • OCTOBER, 1957

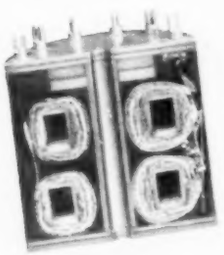
Plastic Sandwich Panels Add to Truck Payload

Miniature electronic components potted in Epon resin by Freed Transformer Company, Inc., Brooklyn, New York

Why **EPON**® **RESINS** for potting:

4 Good Reasons!

1. Outstanding adhesion to metal, glass, plastics
2. Excellent dimensional stability
3. High mechanical strength
4. Excellent dielectric properties



Section of magnetic amplifier coils embedded in Epon resin by Westinghouse Electric Corporation, Pittsburgh, Pa.

EPON RESINS are preferred for potting, laminating, sealing and encapsulating because they offer an almost ideal combination of electrical and physical properties.

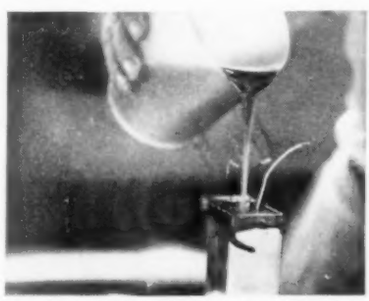
Potting and encapsulating. Epon resins have outstanding adhesive properties. They form strong bonds to metal and glass, provide airtight enclosure of delicate components and vacuum tubes. They also have excellent dimensional stability and can withstand solder bath temperatures.

Sealing. Enamels and varnishes based on Epon resins provide excellent moisture sealing plus outstanding resistance to solvents and chemicals, even at elevated temperatures.

Laminating. Epon resins, laid up with inert fibrous fillers, produce base laminates of superior dielectric properties which can be sheared, punched, drilled and bath soldered.

Adhesives. Solvent-free Epon resin formulations cure at room temperature, with contact pressure alone; form powerful bonds between glass, metal, wood or plastic.

Write for complete information on the use of Epon resins in protective enamels, tool and die materials, etched circuit laminates, transformer and motor sealing compounds.



Potting transformer with Epon resin at PCA Electronics, Inc., Santa Monica, Calif.

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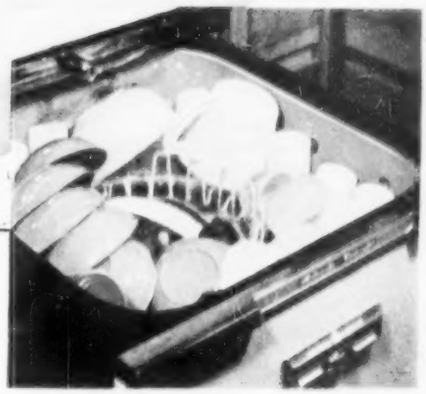
SHELL

New Product Opportunities with Sterilizable

MARLEX* 50

POLYETHYLENE



Articles made of rigid, heat-resistant MARLEX 50 polyethylene can withstand temperatures from −180° to 250°F! Molded housewares are undamaged by boiling hot wash and rinse cycles in automatic dishwashers. Nursing bottles withstand live steam sterilization at 15 pounds per square inch steam pressure.

This new Sales Service Lab at the Phillips Research Center in Bartlesville is equipped with the latest plastics research and production equipment. Here, experienced engineers are developing data on new processing techniques and product applications, available to you through your local MARLEX sales representative.

New product applications for MARLEX 50 polyethylene include syringes, sterilizable pipe and fittings for chemical and food processing, pharmaceutical and food packaging that can be boiled or sterilized before filling, infants' toys, and many more yet to come. MARLEX 50 is odorless . . . nontoxic . . . and highly impermeable.

Bandages, swabs and instruments sealed in tough MARLEX 50 film can be autoclave sterilized without removal from packages. MARLEX 50 is also ideal for molded hospital items that must be sterilized repeatedly . . . such as vials, bottles, tumblers, pitchers, emesis basins, funnels, beakers, bedpans, urinals, trays.

*MARLEX is a trademark for Phillips family of olefin polymers.

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U.S.I.

Vol. II, No. 5

POLYETHYLENE PROCESSING TIPS

HOW CARBON BLACK QUALITY AFFECTS WEATHER RESISTANCE OF POLYETHYLENE

For cable jacketing and many other outdoor applications polyethylene offers substantial advantages over other materials. It is subject, however, to degradation from long exposure to sunlight unless the resin is properly protected.

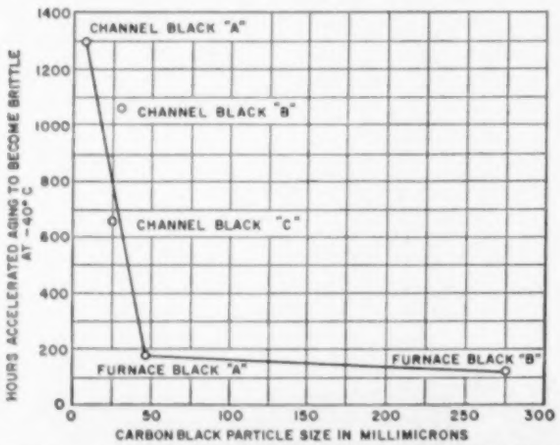
Actually, the aging of polyethylene is the result of a chemical reaction with atmospheric oxygen. Catalyzed by the ultraviolet rays in sunlight, this reaction proceeds more rapidly in outdoor use than is the case with indoor applications. The principal effects of aging are to increase brittleness at low temperature, and to decrease the resistance to stress cracking.

Carbon black dispersed throughout the polyethylene greatly retards this aging, or weathering. However, not all carbon blacks produce the same degree of weather resistance when dispersed in polyethylene. Moreover, the care with which the carbon black is dispersed in the polyethylene is vitally important.

The weather resistance of a polyethylene compound depends on: (1) type and particle size of carbon black; (2) percentage of carbon black in the compound; (3) the dispersion of the carbon black in the polyethylene.

Accelerated aging tests have been devised to approximate the action of years of outdoor exposure.

The graph below shows the great difference in number of hours required in these tests for a polyethylene to embrittle at −40°C when various carbon blacks having different particle sizes are used.



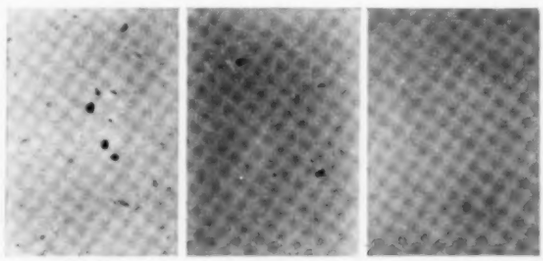
EFFECT OF CARBON BLACK PARTICLE SIZE ON ACCELERATED AGING OF POLYETHYLENE.

The two at right are "furnace blacks", and it will be noted that they are comparatively ineffective. The three at the left are "channel blacks", and obviously, they are many times more effective. This is due to their much smaller particle size – from about 10 to 25 millimicrons, against 50 to 275 millimicrons for furnace blacks.

Weather resistance also increases with the concentration of carbon-black – up to a point. Beyond this point the light screening effect is offset by a decline in other properties.

DEGREE OF DISPERSION IMPORTANT

Carbon black gives maximum protection only when it is thoroughly dispersed in the polyethylene. This presents a difficulty because the smaller the particles, the greater is their tendency to collect into clusters which, once formed, are hard to break up. Tests show that a good dispersion will withstand 15 to 20 times as much exposure to sunlight as a poor dispersion.



POOR **FAIR** **GOOD**

MICROPHOTOGRAPHS OF CARBON BLACK DISPERSIONS IN POLYETHYLENE.

The wire and cable grades of U.S.I.'s PETROTHENE polyethylene resins employ only the finest "channel black" carbon black. Concentration is set at a point which yields the optimum balance of light screening and other properties. Special processing equipment insures thorough dispersion. The result is black polyethylene that withstands long, severe outdoor exposure, yet affords the practical maximum of tensile and other properties.

If you fabricate or use black polyethylene, ask U.S.I. for complete technical data on PETROTHENE resins expressly formulated for weather resistance.

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SPE JOURNAL

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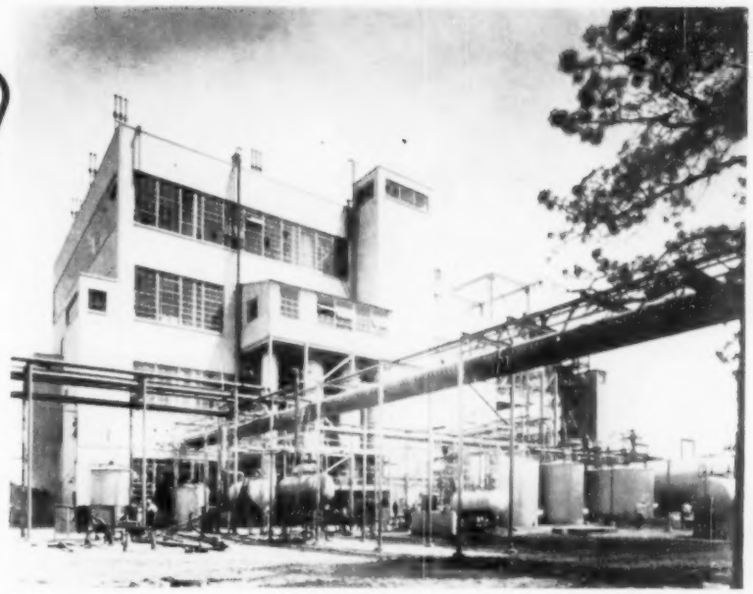

Front view of the four-story building of the new Hercules Hi-fax plant at Parlin, New Jersey, housing Hi-fax processing equipment. It is completely enclosed. Utilities and ingredient handling facilities appear in the foreground.

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From The Editor's Notebook

By JESSE H. DAY

There are times when legal protocol must be observed if you want a court to smile on you. To prevent your getting a frown instead, we hasten to reproduce this letter from our amazingly vigilant Copyright Office.

SPE JOURNAL
Gentlemen:

On page 39 of the August 1957 issue of the **Journal**, in the article on Patents, Trademarks and Copyrights, there is an error, probably due to the printer not having a slug for the copyright symbol, which may have serious consequences. It is very important that the copyright notice be in the statutory form, otherwise, there is very great likelihood that a court would declare the copyright invalid. Furthermore, the Copyright Office would refuse to register a claim to copyright in a work bearing a notice such as described in the article. The correct symbol is a c with a circle around it, not "c" . . .

Sincerely yours,
Richard S. MacCarteney
Copyright Office
Library of Congress

The alert Journal reader will note on page 45 of this issue that we used the correct symbol this time.

Calendar of SPE Technical Meetings

REGIONAL TECHNICAL CONFERENCES
(Programs listed on page 65)

OCTOBER 17, 1957 — Cleveland, Ohio —
"POLYETHYLENES" sponsored by Cleveland-Akron Section.

Chairman—W. A. Messina, 23817 Cliff Dr., Bay Village, Ohio.

NOVEMBER 11, 1957 — Los Angeles, California —
"PLASTICS IN AIRBORNE ELECTRONICS" sponsored by Southern California Section.

Chairman—L. J. Costanza, 29 East 44th St., Los Angeles 58, Cal.

ANNUAL TECHNICAL CONFERENCE

JANUARY 28-31, 1958 — HOTEL SHERATON-CADILLAC, Detroit, Michigan. Sponsored by Detroit Section.

—Featuring 96 Scientific and Engineering Papers on Plastics Research and Education Symposia—

CONFERENCE THEME — "Progress Through Plastics Engineering"

Chairman—C. H. Whitlock, 21655 Coolidge Road Oak Park, Michigan

This Month's Cover:

The van on the cover is 30 x 7 x 7 feet and weighs 9,000 pounds—which is 3,000 pounds lighter than the conventional van.

Plastic sandwich panels make this weight saving possible. This van was originally devised as an airborne trailer for electronic equipment for the Army. Our thanks to Hupp Corp., of Cleveland for sending us the photo.

More about plastics sandwiches, from another source, in the article beginning on page 27.

TYPICAL PHYSICAL PROPERTIES OF FORTICEL

Flow temperature: (°C.) (A.S.T.M.)	D569-48	167—178
Specific gravity	D176-42T	1.18—1.21
Tensile properties:		
Yield (p.s.i.)	D638-52T	3380—5020
Break (p.s.i.)	D638-52T	3470—5240
Elongation (%)	D638-52T	55—66
Flexural properties:		
Flexural strength (p.s.i. at break)	D790-49T	6400—8500
Flexural modulus (10^5 p.s.i.)	D790-49T	0.23—0.30
Rockwell hardness: (R scale)	D785-51	62—94
Izod impact: (ft. lb./in. notch)	D256-43T	2.7—11.0
Heat distortion: (°C.)	D648-45T	59—70
Water absorption:		
% sol. lost	D570-42	0.00—0.08
% moisture gain	D570-42	1.5—1.8
% water absorption	D570-42	1.6—1.8

ANSCO *selects* FORTICEL

Celanese propionate thermoplastic for its new Universal Viewer

Not much larger than a pack of cigarettes, this folding viewer is the most recent addition to Ansco's line of precision photographic equipment. The viewer opens automatically . . . takes both 2¼ x 2¼ and 35 mm transparencies . . . employs a fine lens for perfect viewing.

Companies like Zenith . . . Bissel . . . American Optical . . . Ansco . . . select Forticel because it offers the toughness and high-speed moldability of the Cellulosics – and a big plus combination of better dimensional stability and excellent surface lustre. Qualities like these contribute to consumer approval, manufacturing efficiencies.

If you haven't evaluated Forticel, we urge you to do so. You'll then understand why, in so short a time, Forticel has become a molder's and designer's plastic, and is being written into an increasing number of specifications.
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WITH A COMPLETE EGAN EXTRUSION INSTALLATION

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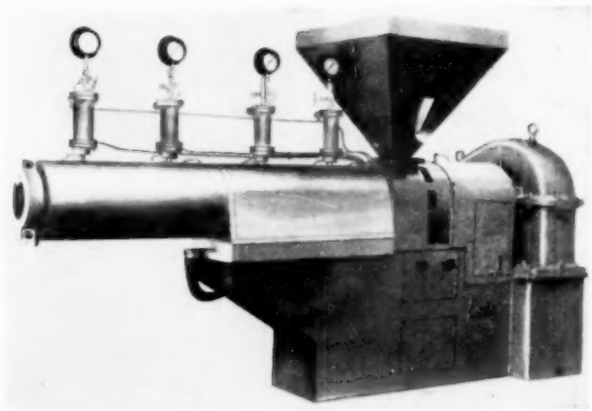
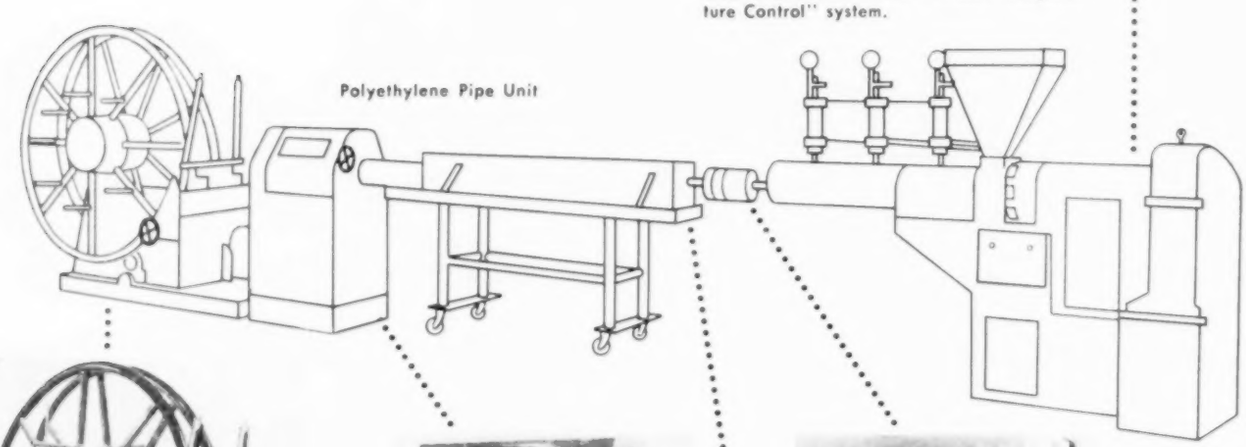
The success story behind every Egan installation is the extruder proper. Egan Extruders with patented "Willert Temperature Control" systems provide automatic, balanced temperature levels, which result in closer tolerance extrusions with greater speed and ease.

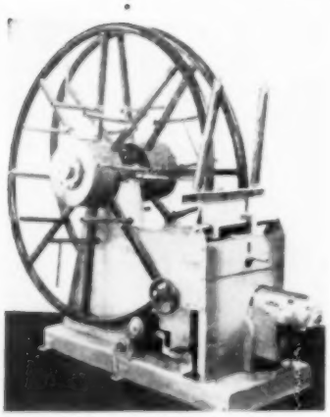
Complete extrusion installations or accessories available for pipe, film, sheet, shapes.



*EGAN EXTRUDERS: pre-set the temperature; "Willert Temperature Control" system takes over, providing completely automatic instrumentation.
*also available without "Willert Temperature Control" system.

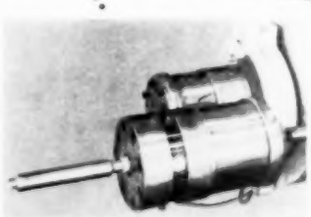


Polyethylene Pipe Unit



COILERS: dual reel type, with or without automatic level wind.

TAKE-OFFS: roller or multiple belt types in diameters of ½"—6" or 3"—14".



DIES: offset or straight-out, with or without extended mandrels.

COOLING TANKS: with vertical and horizontal adjustments.

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ACRYLIC RESIN

- **Greater resistance to mold crazing**
- **Superior color and crystal clarity**
- **Better resistance to haze**
- **Improved processability**

Du Pont LUCITE 129 general-purpose molding powder has been recently completely redesigned to incorporate new processing properties which complement its proven superior end-use performance. A full year's experience with the new "Lucite" 140, now the standard of the industry, has been utilized in modification of the new LUCITE 129.

As a result, the new formulation has much greater resistance to mold crazing and has also increased resistance to blushing or becoming hazy under exposure to high temperatures and high humidity.

The characteristic color and sparkle have been improved, and the polymer stability has been increased in such a way that the material can be reworked several times without significant loss of the original color qualities.

Processability also has been improved in both the granular and molding-powder form. The granular LUCITE 29 and the powder LUCITE 129 are both specially adapted for vacuum extrusion work. In molding over the entire temperature range, this improved LUCITE 129 will provide thicker sections free from bubbles and thinner sections without surface blemishes.

All physical properties proven outstanding in Du Pont LUCITE 129 over the years have been retained in this new composition. The excellent outdoor durability, the sparkling clarity, and the faithful light-transmission properties are unchanged.

Adoption of the new formulation of LUCITE 129 will bring improved properties to molder and end user. Perhaps this exceptional combination of properties will suggest a profitable new product for you. For further information, write to E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 4510, Du Pont Building, Wilmington 98, Delaware.

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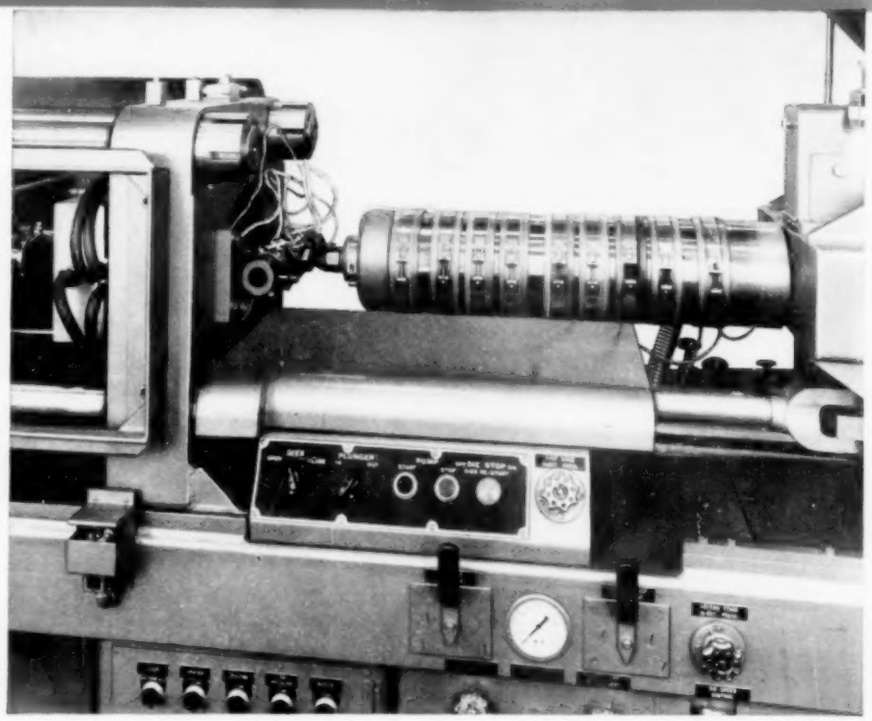

Here are the big new features that set today's 175T—4 6 oz. REED way out in front for high-speed, automatic operation:

New twin nozzle arrangement means faster, sprueless automatic molding. A Reed-Prentice exclusive, this multiple nozzle (shown above) makes it possible to use the 175T with a standard single nozzle when desired, increases the machine's versatility. Changing to this optional accessory can be done in minutes.

New Jumbo heating cylinder shown above has twice the capacity of a standard 175T heating cylinder. Available as optional equipment, the new Jumbo assures speedier plasticizing and more material for fast, automatic molding and heavy shots.

New high-torque, 15 H. P. motor is now standard equipment on the 4/6 oz. REED. It cuts dry cycle time to 5.7 seconds. In sustained production, a 175T with twin nozzles is now molding 2 one-pint containers on a 6-second cycle—1,200 pieces an hour.

New long-stroke 175 TL—4/6 oz. model (below) now provides infinite mold stroke adjustments between 6″ and 12″. It is ideal for deep draw containers.

Get complete information on these new REED features by calling your Reed-Prentice Sales Engineer today.

Engineered for Modern Molding

"YOU CAN'T BEAT NEW REEDS FOR AUTOMATIC OPERATION"

SAYS ERIK E. ERIKSON,
President of Detroit Plastic Products Company

"As far as I'm concerned," says Mr. Erikson, "the ideal production set-up would be new REEDS, running automatically. Of our 9 machines, 4 are less than two years old, and I plan to replace the others as rapidly as possible. I'm thoroughly sold on the benefits of these latest REED models—they're rugged, fast and well-designed. Using them on automatic operation, we've proved that we get high volume and quality at minimum cost, can improve production per machine as much as 25%."

Mr. Erikson has 8 of Detroit Plastics' 9 REEDS on one production line in this modern plant. In telling why he found the new REEDS so superior, he cited two examples: (1) a 175T—4/6 oz. machine that has run over 20,000,000 small nylon rollers with no trouble whatsoever; and (2) a 400T that outproduced the old 16 oz. REED it replaced as well as competitive 16 and 20 oz. machines by as much as 30% on a 52-cavity mold for small model cars.

It costs you nothing to find how much you can gain by investing in new REED equipment. Your Reed-Prentice Sales Engineer will be glad to arrange a free mold demonstration test, or to make a production survey which will show how new machines can boost your present output. Call him today, or write to our main office in Worcester.

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- **Elongation values of 30 to 40 per cent.**
- **Impact strength 25 per cent higher than comparable materials.**
- **Improved extrudability, giving increased production rates.**
- **Better gloss and surface grain.**
- **No contamination by dust or foreign particles.**

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FOR LARGE SECTIONS

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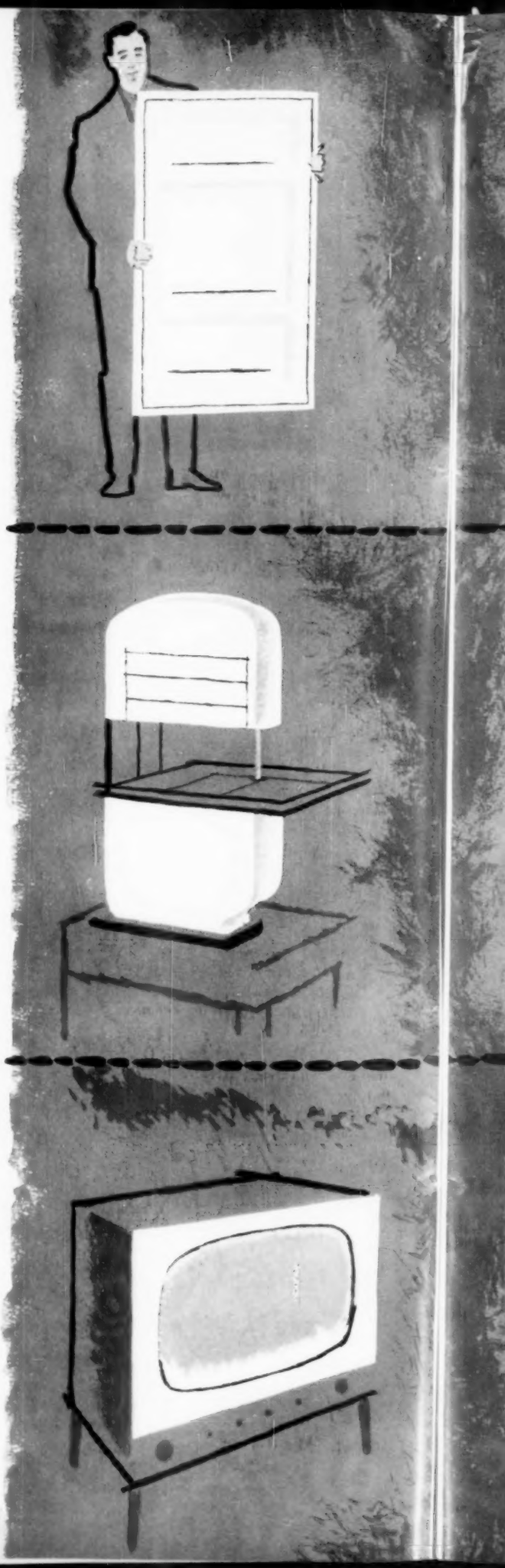
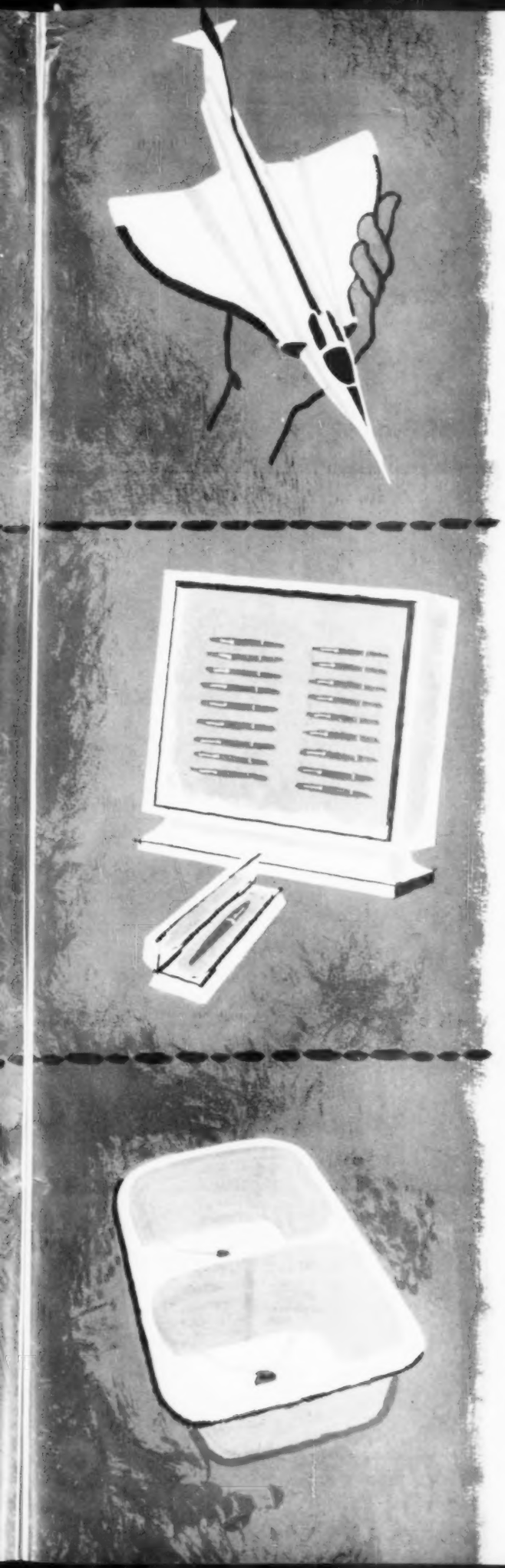
For example, it has an elongation of more than 30 per cent in extruded sheet, permitting sufficient expansion and contraction of vacuum-formed sheets under varying conditions. This feature provides a great reduction in refrigerator door liner cracks around metal fixtures.

HIGHER IMPACT STRENGTH

The high rigidity of TGD-6000 permits thinner door liners and lessens or eliminates need for reinforcements. Even at sub-normal temperatures, this BAKELITE Brand Styrene has excellent resistance to shock fracture. Its impact strength is 25 per cent greater than that of other leading impact styrenes.





BETTER APPEARANCE

The high heat stability of BAKELITE Impact Styrene TGD-6000 results in an improved surface appearance. Uniform colors and absence of streaking are also evident. Color stability is excellent even under heat polishing.

PRODUCTION ECONOMY

The enclosed system of manufacturing this material eliminates contamination by foreign particles. In extrudability, TGD-6000 is superior to any other material of its type. It results in fast extrusions of uniformly high quality on conventional equipment. In vacuum-forming, TGD-6000 demonstrates its excellent strength and elongation. Highly detailed designs and deep draws are formed without cracking, breaking, or warping at the corners.

APPLICATIONS

In addition to refrigerator door liners, other articles suggest themselves for vacuum-forming from extruded sheets of TGD-6000:

DISPLAYS • SIGNS • TOYS • HOUSEWARES • TELEVISION MASKS • HOUSINGS AND GUARDS • NOVELTIES

For details on this new BAKELITE Impact Styrene, write Dept. ZZ-171 and ask for the TGD-6000 booklet.

TABLE OF PROPERTIES

Tensile Strength, psi	3400
Elongation, %	30
Izod Impact Strength, ft.lb. in. @ 23° C	1.0
@ 0° C	0.85
Modulus of Elasticity in Flexure, psi x 10^5	3.6
Flexural Strength, psi	8000
Hardness, Durometer D	80

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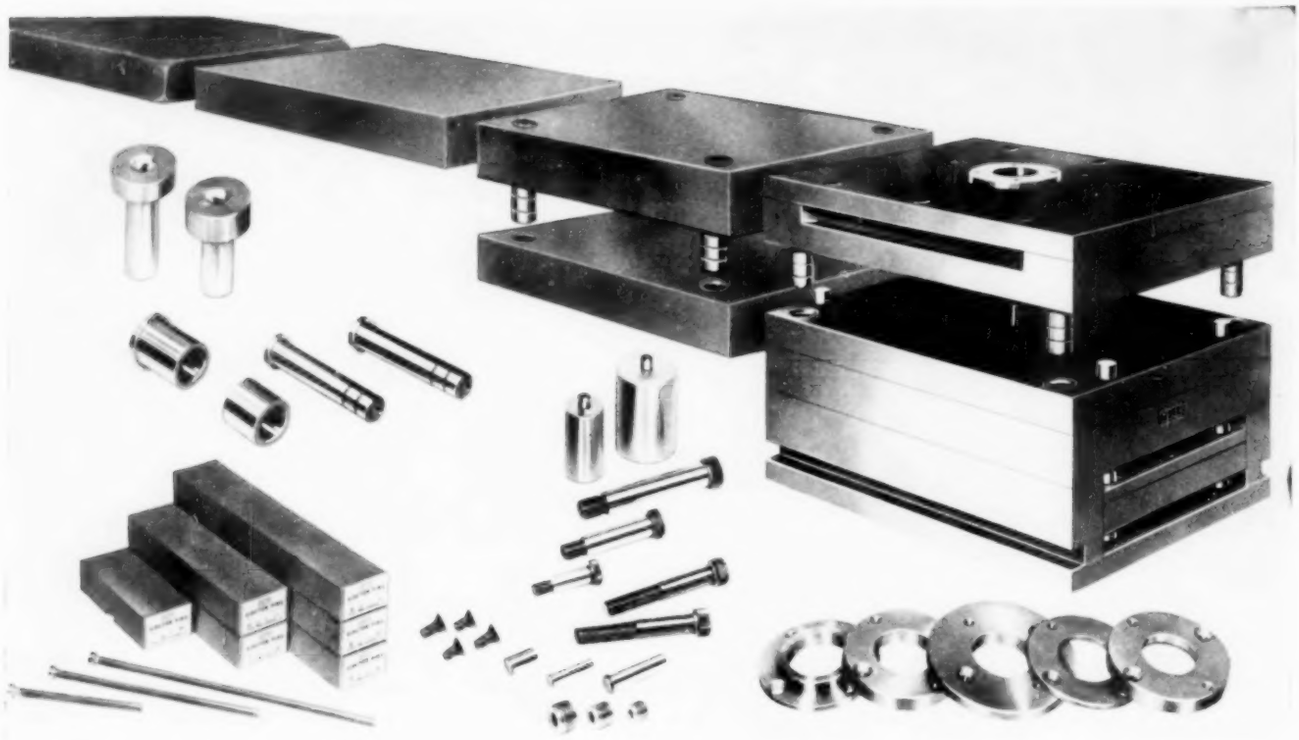

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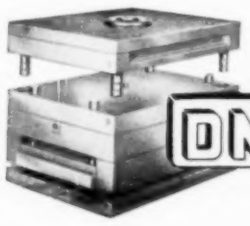

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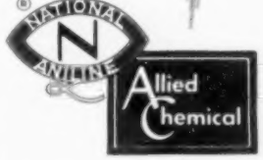

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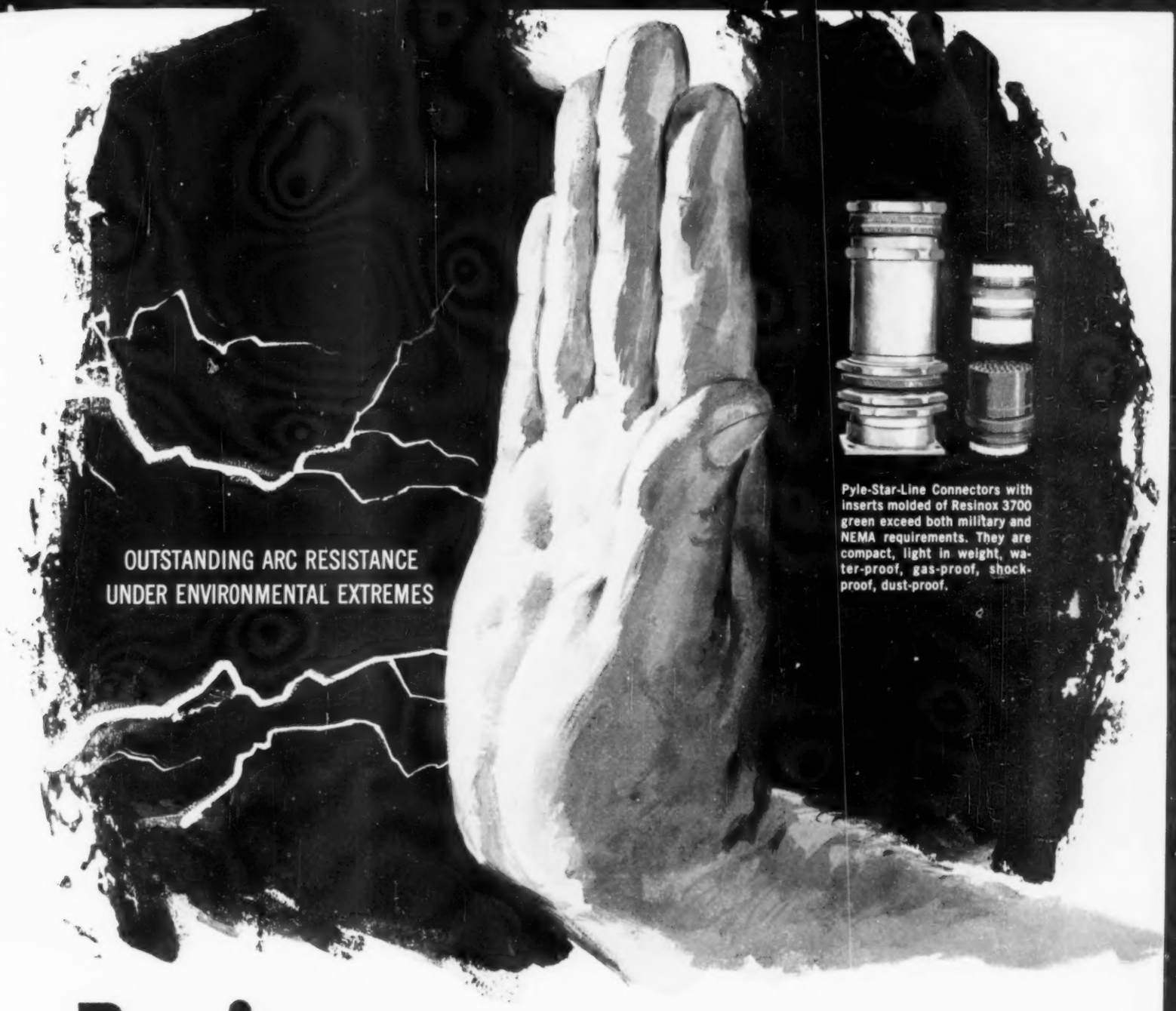

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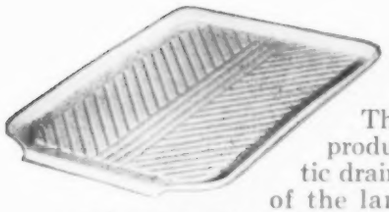

The mold which produced this plastic drainboard is one of the largest plastic molds ever built on the west coast. A block of CSM 2 was the steel used . . . obtained from local *Crucible warehouse stock*. L. D. Plastic Tool and Die Co., South Gate, California, built the mold for Alladin Plastics, Inc., Los Angeles.

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Information regarding Tenite also can be obtained from local representatives listed under "Plastics—Tenite" in the classified telephone directories of the following cities: Atlanta, Chicago, Cleveland, Dayton, Detroit, Houston, Kansas City, Leominster (Mass.), Los Angeles, New York City, Portland (Ore.), Rochester (N. Y.), St. Louis, San Francisco, Seattle and Toronto—elsewhere throughout the world, from Eastman Kodak Company affiliates and distributors.

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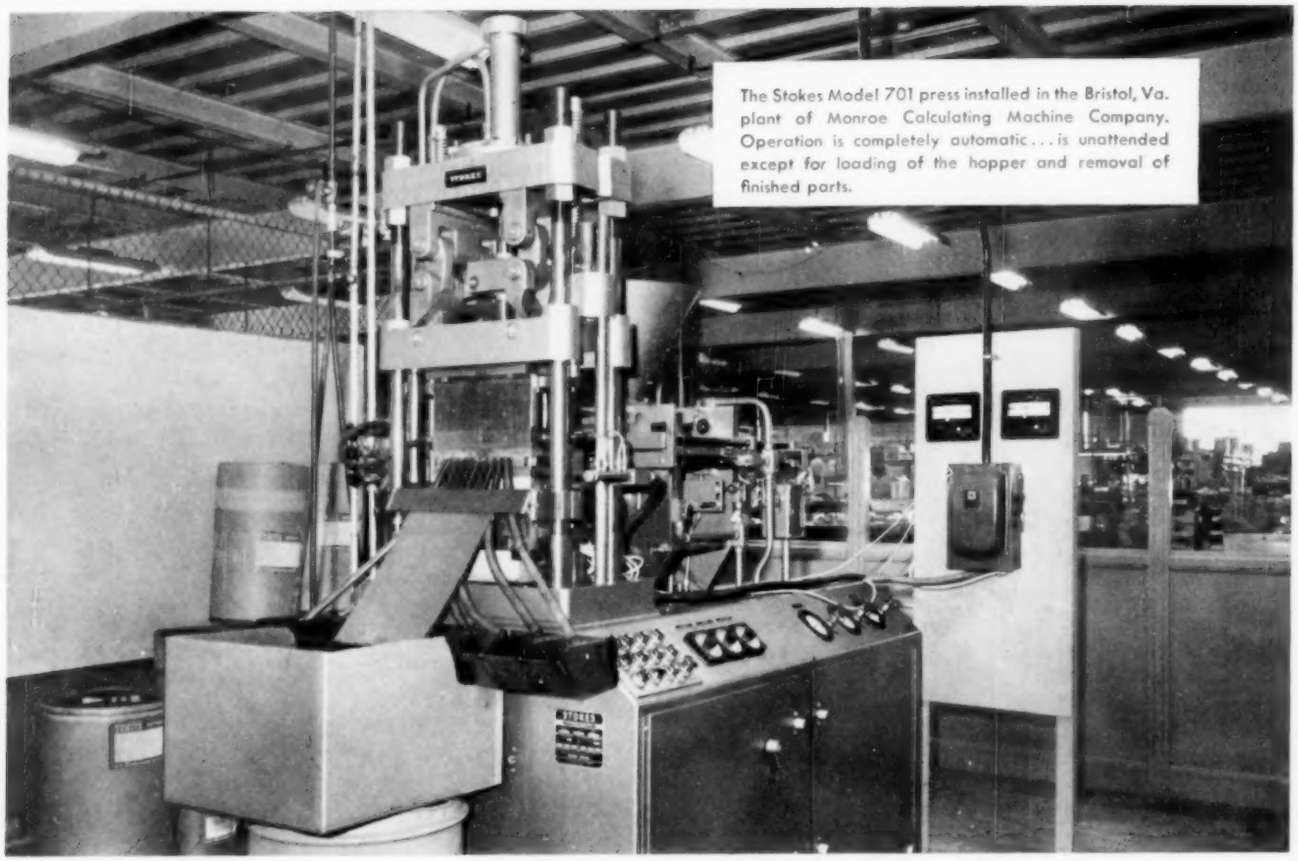

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The Stokes Model 701 machine often economically replaces 4-ounce or larger machines since freedom from the labor factor allows the number of cavities in the die to be planned for optimum production requirements. It does not require special attachments or extra-cost gimmicks. The automatic features are integral. Its precisely repeated automatic cycles provide a higher degree of uniformity and quality of finished parts. The patented Stokes ejection system positively clears all parts and runners from the die. Secondary protection is provided by the use of the more common low-pressure close. The completely self-contained vertical design of the Stokes 701 saves floor space . . . permits easy attendance . . . and facilitates mold set-up.

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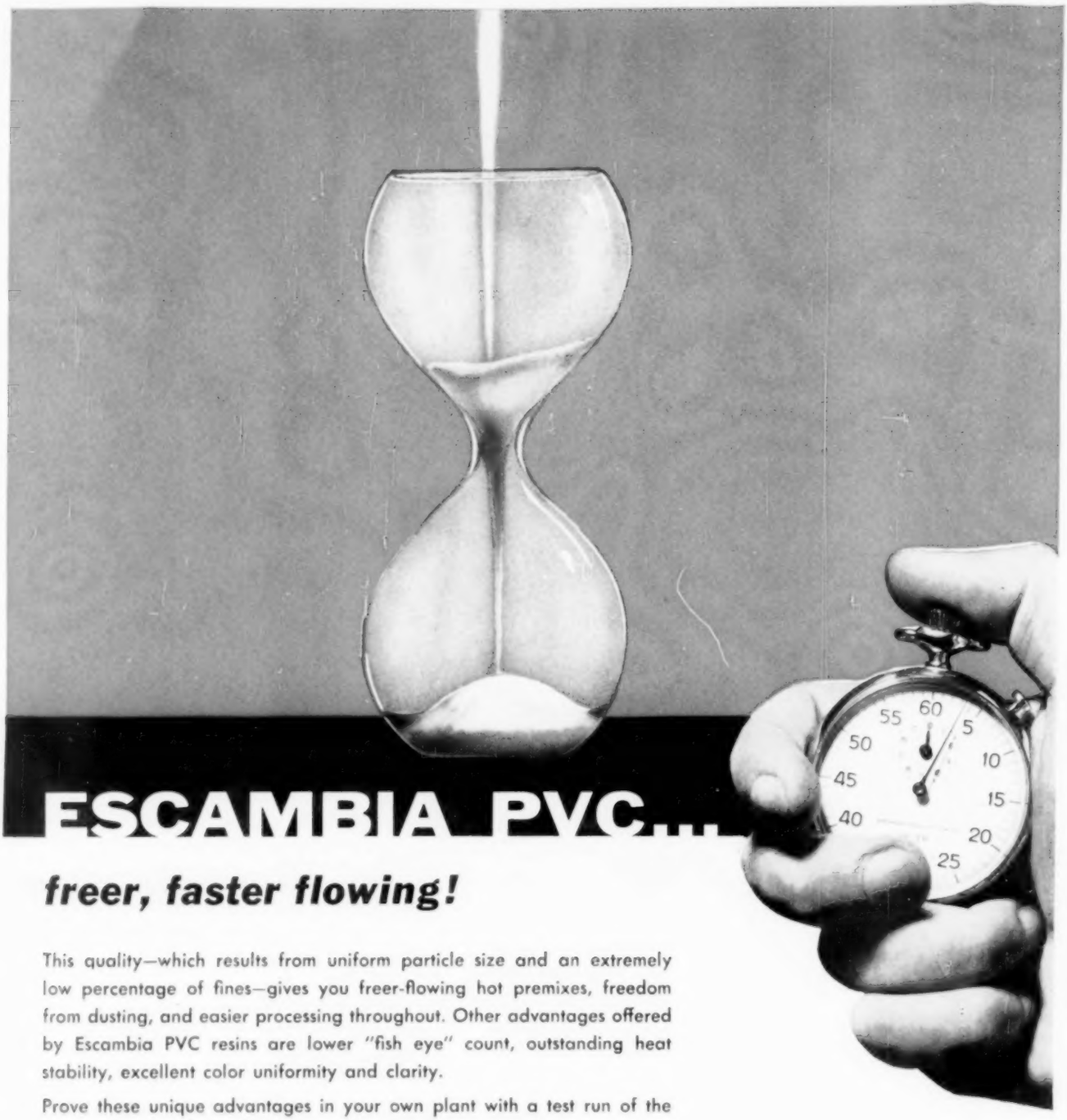

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Plastics Sandwich Construction

G. D. Miller and H. J. Waite

The Dow Chemical Co.
Midland, Michigan

. . . the great variety of materials that can be used for plastics sandwich construction enables the designer to apply the "sandwich" to a great variety of uses . . .

A "sandwich construction" is a three-ply laminate consisting of a lightweight core bonded to high strength facings or skins. The great majority of panel constructions in the past have not been structural sandwiches. They have been heavy high strength faces often mechanically fastened together, strong and rigid enough to perform a desired job by themselves. Designers and engineers, however, have become increasingly aware of the advantages to be gained by use of the more efficient structural composite of facing, core and adhesive. This is not to imply that the structural sandwich is entirely new. The basic principle of spaced facings was discovered about 1820 by a Frenchman named Duleau and panels utilizing asbestos board skins with vegetable fiberboard cores were used as early as World War I. During World War II the trend to more efficient use of labor and materials resulted in increasing use of panels. Not until the past ten years, however, with the development or adaptation of new materials, the majority of which are plastics, has the tremendous potential in the field of sandwich construction been recognized.

The range of core materials for panel construction has been broadened considerably by plastics. Previously known core materials of wood products, expanded glass and gypsum and in honeycomb form metals, cotton fabric, and paper have been supplemented by thermosets and thermo-plastics in expanded form. Polystyrene, cellulose acetate, polyurethane, phenolic, silicone, and epoxy foams are currently being used.

Panel facing materials include phenolic, silicone, epoxy, urea formaldehyde, melamine formaldehyde and polyester plastics with such reinforcing as fibrous glass, cotton duck and paper. Unreinforced polystyrene sheet is finding facing application as well. To obtain greater panel durability and impact resistance these facing materials are often supplemented by use of a sub-facing or sub-skin of plywood, hardboard, metal, or asbestos cement board between the core and exterior facing material.

Many adhesives currently used in sandwich construction are plastics of either thermosetting or thermoplastic type. Many elastomeric adhesives are modified with these resins as well. Generally speaking, thermosetting adhesives including polyurethane, phenolic, silicone, epoxy, urea formaldehyde, and resorcinol plastics prove superior in structural panel applications.

Combinations of these plastic cores, facings, and adhesives with each other and with nonplastic components have given the architect, the designer and the engineer considerable flexibility in selection and design of structural sandwiches. By proper choice of materials and intelligent design the desired combination and proportion of these panels properties can be obtained.

1. Durability of the panel; its resistance to weathering, moisture, and heat.
2. Structural properties; this includes flexural strength, stiffness, impact strength and other basic physical attributes.
3. Panel weight and compactness.
4. Thermal insulation value.
5. Fire resistance.
6. Appearance.
7. Cost.

In the design of a panel it is important to keep in mind not only which of these properties are desired but also that the material components complement each other; that is, none of the components should be over or under designed, penalizing the panel economically.

This paper is a slightly condensed version of the paper presented at the Thirteenth SPE Technical Conference.

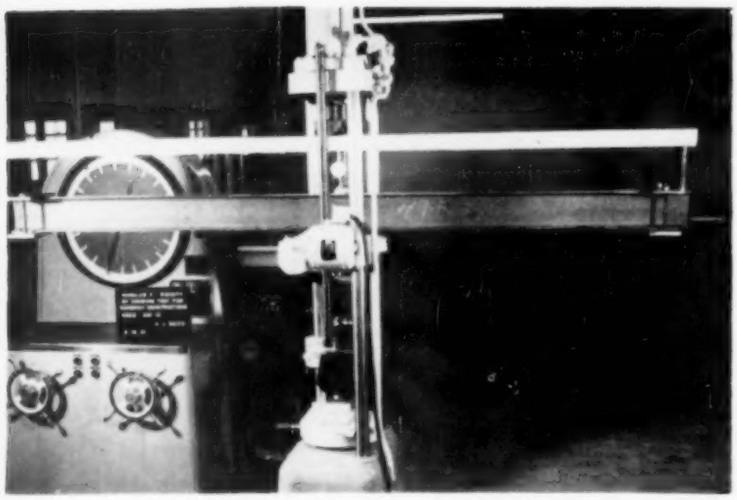
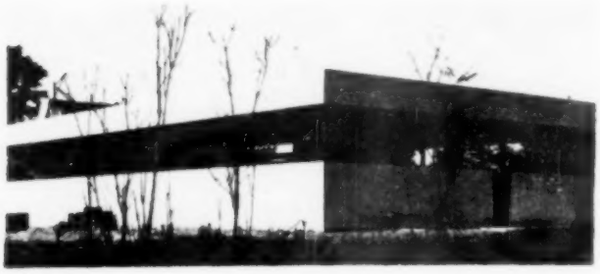


Figure 1. (left) Bending tests establish flexural strength and rigidity of panel.

Figure 2. (below) Machine shop built using 4 x 8 foot panels with 2" expanded polystyrene core.



The basic function of the core is to position and stabilize the facings. As the bulk of a panel is the core it is essential that this component be lightweight, but it must be strong enough to withstand normal shear and compressive loadings. The core may also be required to assist the facings in impact resistance and provide thermal insulation and fire resistance. This component, then, influences primarily panel weight and compactness, thermal insulation value, and fire resistance.

The facings of a panel carry the major applied loads and normally possess high tensile and compressive strengths and moduli. They determine primarily panel durability and structural properties. Sub-skins may be used to supplement some of these structural properties. The facings also have considerable bearing on fire resistance and essentially establish the panel appearance.

The adhesive is of no less importance than the two more obvious components since it must effectively bond the facing to the core. To accomplish this it should exhibit greater shear strength than the core and adequate tensile strength and sufficient rigidity to eliminate creep at design loads. It must be durable, not deteriorating with age or service temperature. This component also has a great deal to do with panel durability and structural properties.

The basic design of a sandwich construction is only proven by performance tests. The simple bending test (Figure 1) is employed as a positive check on the flexural strength and rigidity of the panel as well as its general structural capacity. Long-term tests of this nature are often used to determine possible creep characteristics. Other tests conducted for more specific physical properties are column, spot bearing, and impact loadings.

An accelerated aging test developed by Forest Products Laboratory has found considerable application for checking the durability of sandwich panels. It is a severe test that definitely upgrades panel construction. However, the upper cycling temperatures of approximately 212°F. preclude many materials, including most thermoplastics.

The aesthetic and functional design of sandwich construction is dependent upon the requirements of each application. The fields of architectural building, transportation, refrigeration and aircraft prove the versatility of structural sandwiches in their ability to meet a wide range of requirements.

Aircraft Application

In aircraft applications the structural, temperature, and lightweight requirements are almost without exception very high. Temperature requirements in aircraft design necessitate use of thermoset plastics. Silicone resins are being used with glass cloth to make laminates capable of functioning continuously at temperatures of 500°F. and intermittently to temperatures of 1000°F. Sandwich constructions shown here are being developed utilizing silicone foam as a core with these silicone glass facings for the outer skin of high speed aircraft. Both urethane and foams are presently being employed as a core in aircraft radomes.

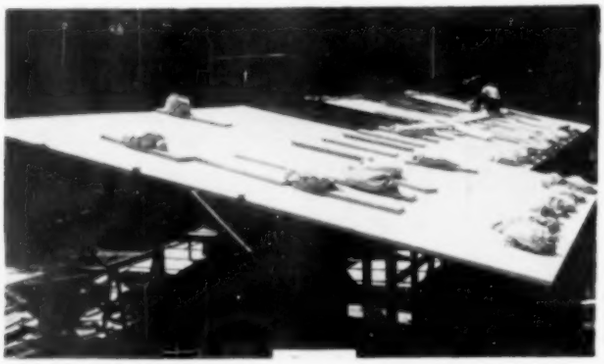


Figure 3. Home roof construction using plastics panels provides support and decoration.

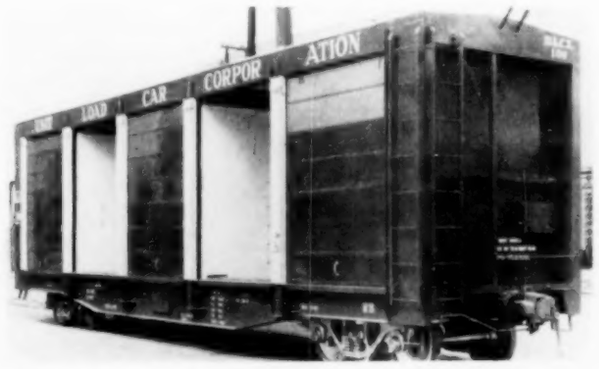


Figure 4. Lightweight insulating panels are used in refrigerated car construction.

Architectural Uses

In the architectural building field the majority of structural sandwiches presently used are curtain wall panels. This type panel is nonload-supporting, requiring only moderate structural strength to resist stresses from wind load, thermal expansion and contraction, impact and denting.

This machine shop in Michigan (Figure 2) utilizes this type of curtain panel on a skeleton steel structure. The panels, 4' by 8', are composed of a 2" thick expanded polystyrene core, outerfacing of polyester reinforced with fiberglass cloth and sub-skins of 1/8" cement asbestos board. Each panel will support an ultimate load of 660 pounds per square foot uniformly distributed on a 4' span. This provides a large factor of safety for design wind loads of 30 pounds per square foot, equivalent to a wind velocity of about 100 m.p.h. A wall panel designed to resist such wind loads will usually have adequate strength for all other needs. The 2" foamed polystyrene core gives this panel superior insulating qualities with a U-factor of .12 BTU/hr./sq. ft. of wall area. This thermal resistance is more than twice that of a conventional 12" brick wall, furred, lathed and plastered. The polyester facings are available in a variety of colors and provide a prefinished decorative wall of excellent appearance and weatherability.

Fire Resistance

Fire resistance is also an important consideration for application in areas rigidly controlled by codes. Generally speaking, building codes, though not always keeping pace with advanced technology, have improved considerably in the past decade. Where formerly 8" to 12" masonry walls with four-hour fire ratings were required, curtain walls of incombustible materials having fire ratings of one to two hours are now acceptable. Some codes are now requiring only incombustible panels with no hourly fire ratings. Very few industrial panels have sucessfully met two or even one-hour fire ratings.

Panels capable of supporting light roof loads encountered in small one-story buildings such as homes are not difficult to produce. This type of structure requires load bearing walls to support 750 to 1000 pounds per linear foot in column strength. One home utilized panels of 2" polystyrene foam core faced with 1/4" melamine coated plywood facings. A modified phenolic adhesive was used to bond these components together. One of the most serious problems in panel installation is the joints. A miniature sandwich spline with a phenolic adhesive was employed to joint the 4' by 8' panels in this plastic house.

The roof structure of the home (Figure 3) was built of an all-plastic panel. Glass reinforced polyester facings .018" thick were bonded to a 2" polystyrene foam core by means of an epoxy adhesive. This roof panel, spanning joists on 48" centers, has no additional building material added. The panel functions simultaneously as exterior protection and interior decoration. It will support 150 pounds per square foot on this 4' span, giving a large factor of safety over design figures of 30 pounds per square foot for roofs.

The aluminum faced panels used in a new school typify the pleasing appearance of such units for exterior building walls. The speed of erection saves high field labor costs and decreases construction time. Buildings of this type can be expanded or revised quite readily. A 2" expanded polystyrene core was utilized with 1/16" aluminum skins in this construction.

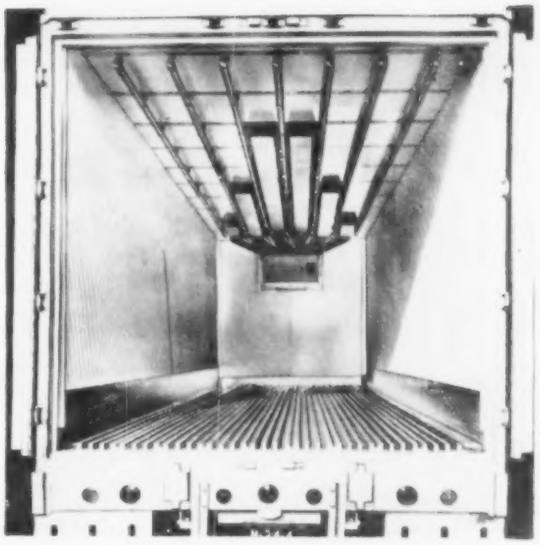


Figure 5. Refrigerator truck uses plastic panels.

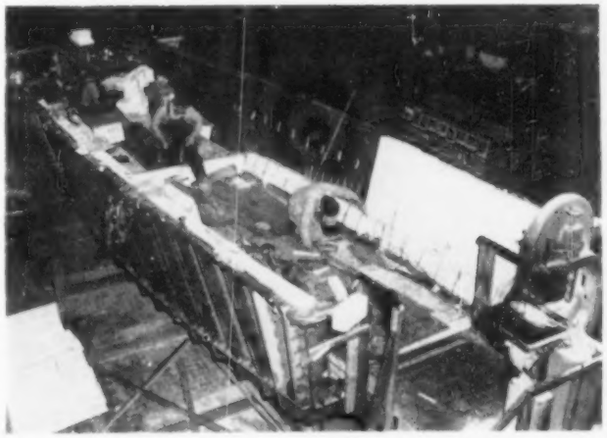


Figure 6. The Navy builds boats of unique sandwich.

In the field of transportation the lightweight and compactness available in panels are greatly desired. In refrigerated vehicles well insulated panels are used to particular advantage. The floor, ceiling, walls, partitions and overhead roll-away doors of this new type of refrigerated railway cars (Figure 4) are panels of polystyrene foam core with reinforced polyester facings and 1/4" fir plywood sub-skins. The lightweight overhead doors are the feature of the car making it possible to load and unload the car with fork trucks in a matter of minutes compared with 10 to 16 man-hours normally required to hand load and unload the conventional car.

The Fruehauf Trailer Company has utilized panel construction extensively. (Figure 5) Note the combination of smooth surfaced panels in ceiling with corrugated panels in side walls of this trailer to induce natural ventilation. The ceiling panel has polystyrene foam core with glass reinforced polyester facing. The side walls are of same construction with aluminum subskins for higher impact resistance.

The excellent water resistant properties of most plastics and their excellent thermal efficiency when expanded mark them as natural materials for the field of general refrigeration.

(Please turn to Page 81)

Effect of Lay-up Configuration on . . .

Flexural Properties of 181 Glass Cloth Laminates

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For some time it has been recognized that 181-style glass-cloth laminates are often anisotropic with respect to flexural properties in the plane of lamination. This difference is usually attributed to the fact that there are slightly more warp yarns than fill yarns per unit area; cross lamination is often employed to overcome this anisotropy. Not well understood, however, is the effect of glass fiber orientation and position on the flexural properties of thin laminates utilizing about four to six plies of cloth. In such laminates the effect of fiber orientation and placement can be much greater than that due to warp-fill differences.

This paper discusses the effect of fiber location on the flexural properties of two different types of four-ply layups and also shows how the flexural strength and elastic modulus in bending vary with resin content. An estimate of the strength of the laminate based upon the strengths of the glass and resin and their orientation and position in the laminate is given, and the disappearance of fiber orientation effects with increasing number of plies of cloth is shown.

Style-181 glass cloth, which is widely employed in the manufacture of aircraft parts, is commonly used as a standard cloth for the testing and evaluating of laminating resins. Since it is relatively thin it may be used to advantage in thin as well as thick laminates, and it has nearly equal strength in both the warp and fill directions. There are nominally 57 warp yarns and 54 fill yarns per inch. Fill yarns are parallel to the axis of the roll of cloth and warp yarns are perpendicular to the axis of the roll.

Style-181 cloth is of the long-shaft satin-weave type —in this case an eight-harness satin weave. (See Figure at top of page) Each warp and fill yarn is woven over seven other yarns and under one. This arrangement results in a somewhat sleazy cloth with better forming characteristics than those that would be found in a square or plain weave in which each yarn is woven over one yarn and under one.

It is important to note that the long-shaft satin weaves have **all warp yarns predominantly on one side of the cloth** (about 7/8ths of each yarn for 181 cloth) and **all fill yarns predominantly on the other** (Figure above).

Symbols

In order to show clearly the configurations used and to aid in correlating the experimental results with the analytic estimate of strength, a system of symbols was devised. Figure 2 shows a typical panel and how the test specimens were cut from it. The cutaway in each of two sides of the panel shows the layup when viewed from that direction. In other words, cutaway A_1 is merely panel A viewed from one direction, and A_2 is a view of panel A after it has been rotated 90 degrees. Warp yarns are shown in white and fill yarns are shown in black. Notice that if panel A is made by using layup A_1, layup A_2 would also result at 90 degrees and vice versa.

Figure 3 illustrates the four configurations studied in these tests. The symbols used are similar to those in Figure 2 except that only the straight portion of the yarn is drawn since it represents the position of approximately 7/8ths of the yarn in a given ply. In layup B_1, for example, the upper white circles and the upper black rectangle represent the top ply of cloth. The predominant warp pattern of this ply is on top and in the same direction as the span in the flexural test.

Since the symbols used in Figures 2 and 3 are some-

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what complicated and time-consuming to reproduce for ordinary discussions, the simplified symbols also shown in Figure 3 have been devised for discussing layup configurations.

Discussion

In the flexural tests performed the lower fibers were placed in tension and the upper in compression. It is apparent that only those fibers placed in tension or compression along their axes can have an important effect on the strength of the structure. Fibers whose axes lie in the direction of the span in the flexural test will therefore be called **favorably oriented fibers.** The "direction of test" in a laminate is taken here as the direction of the span in flexural testing. "Fiber orientation" will be used to designate the direction in which fibers lie with reference to the direction of test, and "fiber placement" or "position" indicates the location of the fibers with reference to the neutral plane of the laminate. In fabricating the laminates, the warp yarns were laid in the same direction for all plies so that the directional difference in strength in laminates due to differences in the number of warp and fill yarns would be isolated.

Prior to the experimental work, an attempt was made to estimate the strength of the various layups analytically. This estimation was based particularly on the number of favorably oriented glass fibers and the position of these fibers with respect to the neutral plane of the laminate. For example, A_1 should be stronger than B_1 since in A_1 the second and third plies have their favorably oriented fibers farther from the neutral plane than those in B_1 (See Figure 3). An example analysis will be given in a separate section below.

The importance of the fiber locations can best be shown by studying the strength formula for a centrally loaded simple beam:

$M = FI\,c$

where

M = the moment, a function of the load-carrying capacity of the specimen

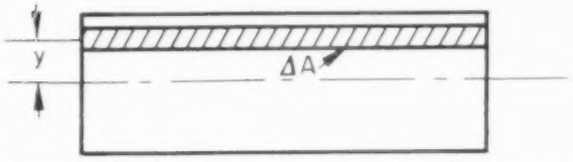
c = the distance from the neutral plane to the critical outer fiber

F = the allowable stress of the composite beam, a function of the ultimate strengths of the resin and glass and the bond between them

I = the moment of inertia.

M is directly proportional to I, which is approximately equal to:

$I = \Sigma y^2 \Delta A$



By considering the cross section of a single filament as an increment of area ΔA, it is apparent from the equation that the contribution of individual fibers to the moment of inertia depends upon the square of their distance from the neutral axis. Because of this and the fact that the glass is much stronger than the resin, the advantage of placing the glass fibers at the maximum distance from the neutral axis may easily be seen.

Results

In order to eliminate the variable of resin content, two panels were made from the A_1-A_2 layup with different resin contents by using shims of various thickness as lands in a panel mold. The test values of flexural strength

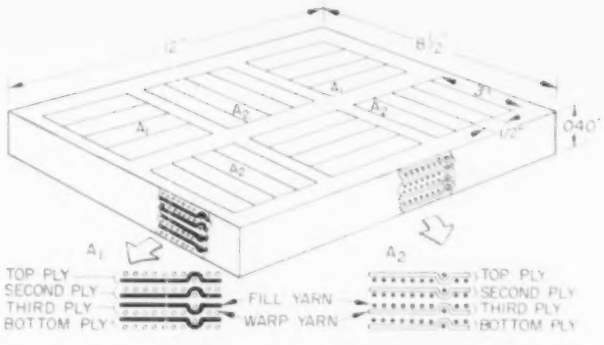
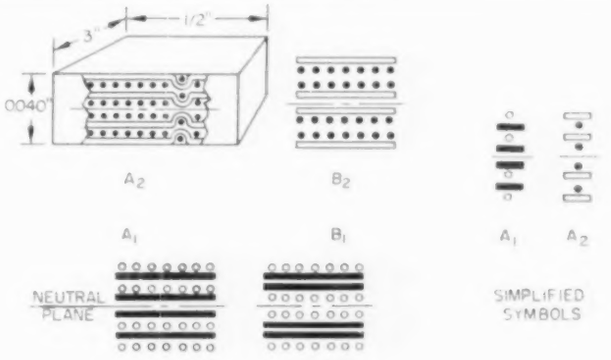


Figure 2. Diagram of a typical panel showing layup symbols and specimen position.



NOTE: ALL SYMBOLS ARE SHOWN AS CROSS SECTIONS OF THE BEAMS AS PLACED IN TEST

Figure 3. Layup symbols.

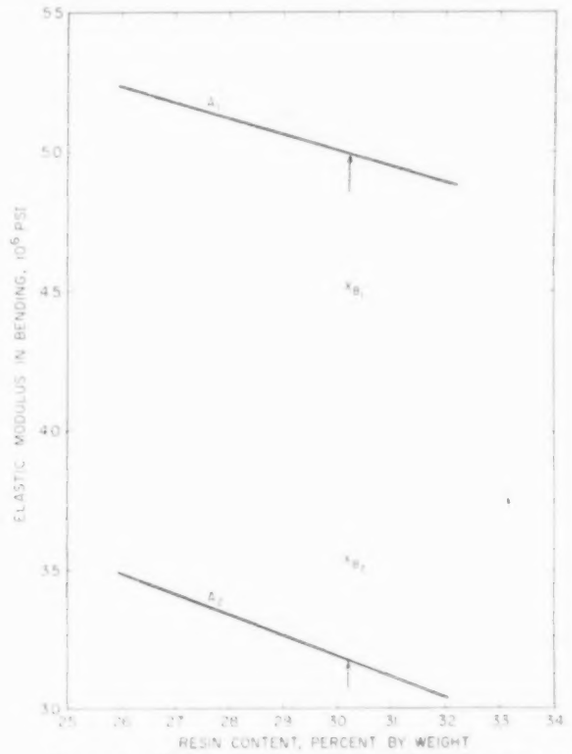
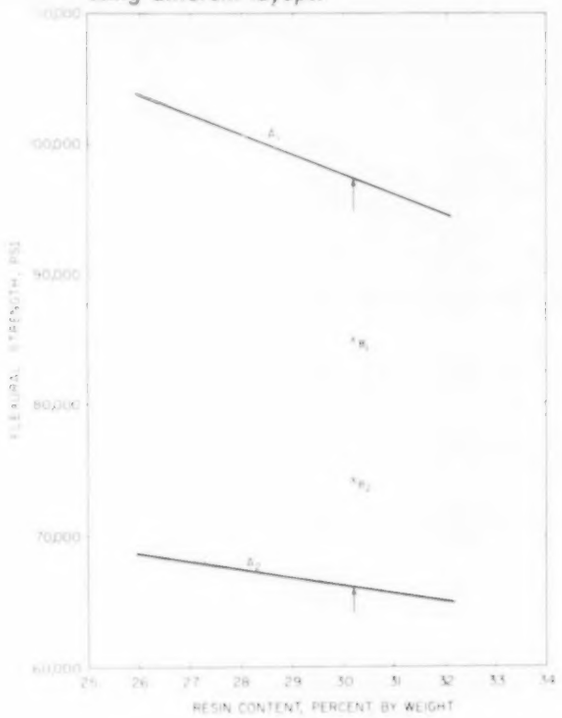


Figure 4. Elastic modulus in bending of laminates made by using different layups.

Figure 5. Flexural strength of laminates made by using different layups.



and elastic modulus in bending were plotted against the resin content of the specimens.

Least-squares lines of best fit were found and are shown in Figures 4 and 5. Only one panel was made from the B_1-B_2 layup, and it had a mean resin content of 30.2%. This value was therefore used in comparing all of the laminates; the arrows in both figures show the strength values for A_1 and A_2 corresponding to this resin content, and the mean flexural properties for B_1 and B_2 are shown on the graphs as X's.

From Figures 4 and 5 it may be seen that both the flexural strength and modulus varied inversely with resin content over the range investigated. It is also immediately apparent that the type of layup configuration employed may be quite important in determining the strength properties of the finished laminate. Note also that panel A was more unidirectional or anisotropic than panel B; in other words, there was a greater difference in directions

Table I

Comparison of Estimated and Test Strength Properties

Layup	Flexural Strength, psi, Estimated	Flexural Strength, psi, Test	Elastic Modulus in Bending, 10^6 psi, Estimated	Elastic Modulus in Bending, 10^6 psi, Test
A_1	101,700(1)	97,250(1)	4.74(1)	4.99(1)
A_2	58,900(4)	66,000(4)	3.28(4)	3.17(4)
B_1	91,600(2)	85,000(2)	4.40(2)	4.51(2)
B_2	68,600(3)	74,300(3)	3.60(3)	3.53(3)

All values are for laminates having 30.2% resin content. The numbers in parentheses give the rank of the layups.

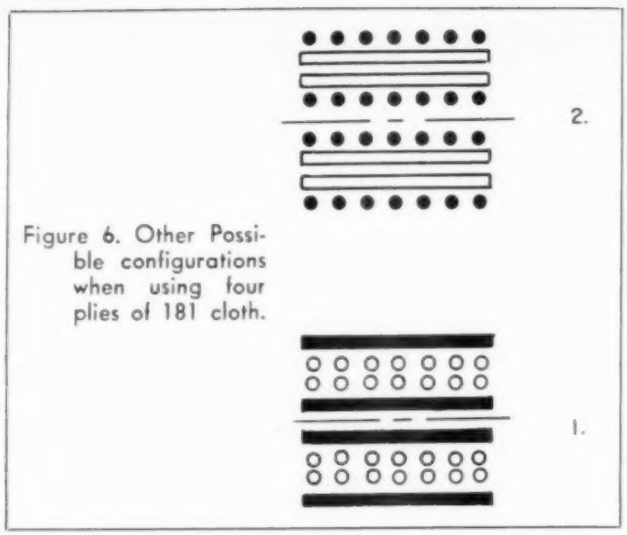


Figure 6. Other Possible configurations when using four plies of 181 cloth.

in A (A_2/A_1 was equal to 0.648 for strength and 0.635 for modulus) than in panel B (where B_2/B_1 was equal to 0.874 for strength and 0.782 for modulus).

The analytic estimate of strength that has been mentioned above predicted both the rank and order of magnitude of both the strength and modulus of the panels. As previously stated, the flexural properties were estimated from the strength of the resin and glass and their distance from the neutral plane of the laminate. The estimated and actual properties are shown in Table I. Although several broad assumptions were made in the analysis, the agreement between estimated and test values is good and shows that the position of the favorably oriented glass fibers within a laminate can have a major effect on the flexural properties. It should be recalled that this effect can occur even with a cloth normally considered nearly balanced in its strength in the two directions.

It is interesting to observe that when the flexural properties in two directions (e.g., A_1 and A_2) in a laminate are averaged, nearly the same value is obtained regardless of the layup employed. Also, when such averages are found for the estimated values, the agreement between estimated and test averages is excellent. Table II shows these data.

Several other configurations are possible when four plies of 181 cloth are used and all warp yarns and all fill yarns run in the same directions from ply to ply. For example, the configurations shown in Figure 6 can be simultaneously obtained. Note that these configurations are the same as B_1 and B_2 except that the warp and fill yarns have been interchanged. Analytic estimates of the strengths of these layups reveal that their strength should

Table II

Average Strength in Both Directions for Test Panels

Panel	Flexural Strength, psi, Estimated	Flexural Strength, psi, Test	Elastic Modulus in Bending, 10^6 psi, Estimated	Elastic Modulus in Bending, 10^6 psi, Test
A	80,300	81,600	4.01	4.08
B	80,100	79,700	4.00	4.02

fall between that of B_1 and B_2. Evaluations of test laminates on a limited basis have shown that this is indeed the case (1).

Effect of Number of Plies

It would be expected that differences in strength properties between directions other than the differences in warp and fill strengths would diminish with an increased number of plies. Laminates utilizing six, 12, and 24 plies were prepared from an A-type layup (i.e., one with the upper half of the plies with the warp up and the lower half with the warp down.)

The values obtained for these laminates were compared with those for the four-ply laminates already discussed (see Figure 7). The ratio of strength properties in the warp and fill directions is plotted versus the number of plies. It may be seen in the figure that the difference in strength in the two directions diminishes rapidly and approaches the warp-fill difference as a limit. This effect is shown experimentally only for the A-type layup which would have the maximum difference in directions; in other layups the effect would probably become negligible much more rapidly.

Experimental

Panels $8\frac{1}{2}$ by 11 inches in size were made from high-temperature phenolic preimpregnated 181-style fiberglass cloth having a Volan A finish. Two panels were made from four plies of cloth with layup A_1-A_2 and one panel from layup B_1-B_2. One of the A_1-A_2 panels was made in a panel mold with 0.040-inch lands, and the other and the B_1-B_2 panel were made in a mold having 0.038-inch lands. One panel each was also made with an A-type layup from six, 12, and 24 plies. The mold employed in making these latter panels had no lands. The landed molds had lands at the sides only and were open at both ends.

Other conditions employed in the making of the

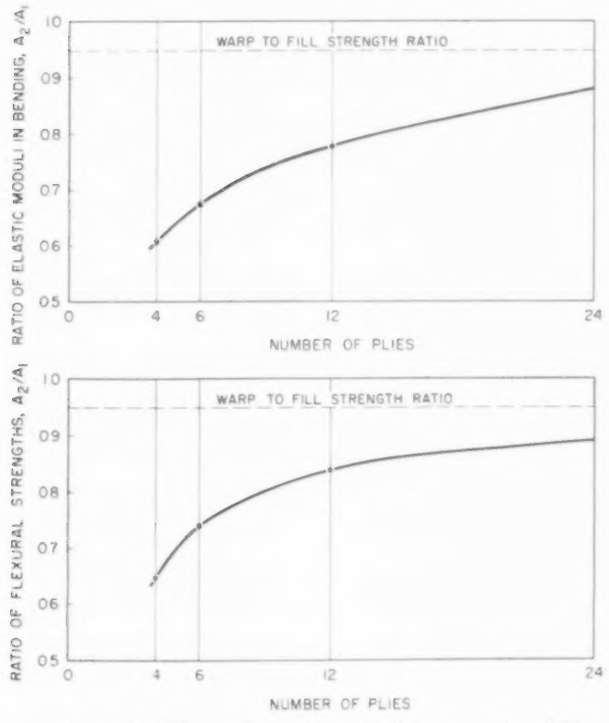

RATIO OF FLEXURAL STRENGTHS, A_2/A_1 RATIO OF ELASTIC MODULI IN BENDING, A_2/A_1
WARP TO FILL STRENGTH RATIO
NUMBER OF PLIES
WARP TO FILL STRENGTH RATIO
NUMBER OF PLIES

Figure 7. Effect of number of plies on ratio of flexural properties in both directions of A_1-A_2 layup.

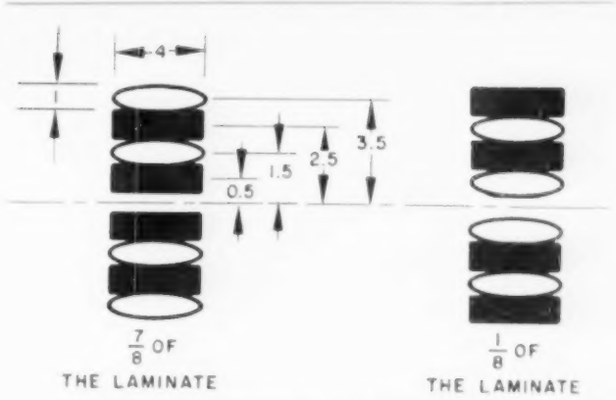


Figure 8. Representation of A_1 configuration for analytic estimate.

panels were:

a. Cure—10 minutes at 300° F for the four-and six-ply laminates and 15 minutes for the 12-and 24-ply laminates.
b. Mold release—a cellophane wrap with one overlap.
c. Kiss (or presqueeze) time—45 seconds for four-and six-ply laminates and one minute 15 seconds for 12-and 24-ply laminates.
d. Press load—40,000 pounds (400 psi based on the projected area).
e. Postcure—in forced-air oven, 17 hours at 275° F plus five hours to 400° F.

Three preliminary panels were made in order to find a "kiss" time that would give laminates with good general appearance. Microscopic examination by means of transmitted light revealed that the panels had an excellent, highly void-free appearance. Specimens were cut from the panels according to the pattern shown in Figure 2, and were tested in flexure as centrally loaded beams according to ASTM method D-790 except that the four-ply specimens were tested using a one-inch span and $\frac{1}{2}$-inch width.

Specimens $\frac{1}{2}$ inch and one inch in width that were cut in both directions from a single panel had previously been broken in order to test for a plate effect in the specimens with the greater width. The one-inch wide specimens gave slightly higher values; when tested by "Student's" t test, this difference was significant at the P=0.07 level for flexural strength and P=0.03 level for flexural modulus. The $\frac{1}{2}$-inch width was therefore chosen; it was also possible to cut more $\frac{1}{2}$-inch wide specimens from the panels.

The resin content of the specimens was determined by ignition for 16 hours at 1500° F after drying for two hours at 230° F; resin contents were based upon the dry weights. The preimpregnated cloth was examined microscopically and found to conform to the 54 x 57 construction specified for 181-style cloth.

Analytic Estimate of Flexural Properties

In the previously described symbols the cross sections of the yarns were conventionally shown as circles for convenience. The yarns within a laminate, however, have been found by means of microscopic examinations to have nearly elliptical cross sections. In the present laminates the ellipses had a major axis approximately four times greater than their minor axis. The analysis of strength in the A_1 layup only will be considered as an example of the method employed.

Let G = the percent of glass in a laminate by weight.
Then

$$G = A_g \rho_g / (A_g \rho_g + A_r \rho_r)$$

where

A_g = % area of glass in cross section
A_r = % area of resin in cross section
ρ_g = specific gravity of the glass = 2.56
ρ_r = specific gravity of the resin = 1.28.

By substitution,

$$1/G = 1 + 0.5\ (A_r/A_g)$$

and $A_g + A_r = 100$.
For G = 69.8% (i.e., 30.2% resin by weight).
A_g = 53.6% and A_r = 46.4%.

The area of glass in the warp direction (A_{gw}) plus the area of glass in the fill direction (A_{gf}) equals A_g.

Note that the same type yarns (ECE-225-1/3) are used in both warp and fill in 181 cloth; the major difference is the number of yarns per inch in the two directions—57 in warp and 54 in fill.
Hence

$$A_{gw}/A_{gf} = 54/57$$

Therefore the area of glass in the warp direction is
$A_{gw} = 53.6/(1 + 54/57) = 27.5\%$ and $A_{gf} = 26.1\%$

Let the A_r laminate be represented as shown in Figure 8 and assume that the minor axis of one ellipse is equal to one and that the major axis is equal to four. The units are arbitrary since they cancel in the final calculations.

The area of one ellipse, therefore, is $2 \times 0.5\ \pi = \pi$.

The area of one repeating section of the cross section of the laminate is equal to eight yarns in width and eight yarns in height, or $8 \times 32 = 256$.

The area of yarns lying in one direction in one repeating section is $32\pi = 100.5$

The percent of cross section occupied by the yarns lying in one direction is $100.5/256 \times 100 = 39.3\%$.

The percent of a warp yarn area which is glass is therefore $27.5/39.3 = 70.1\%$.

The moment of inertia (I_0) of the repeating section about its centerline is $\dfrac{32 \times (8)^3}{12} = 1365.3$

The moment of inertia of one ellipse about its centerline is $\dfrac{(0.5)^3\ 2\pi}{4} = 0.2$.

The area of glass in one ellipse is $0.701\pi = 2.2$

Dietz (2) gives the following equation for the modulus of a laminate:

$E_i I_i$ = the summation from i = 1 to i = n of $E_i I_i$

where

E_1 = the modulus of the laminate
E_i = the modulus of the ith layer

If it is assumed that the laminate is composed of two phases, a resin phase and a glass phase, and that the contributions of their respective moduli are additive, then the equation becomes

$$E_1 I_1 = E_g I_g + E_r I_r,$$

where I_g is the moment of inertia of the favorably oriented fibers about the neutral axis of the laminate and I_r is the moment of inertia of the remainder of the cross section of the laminate. By using the formula for translation of moments of inertia, $I_{na} = I\phi + Aa^2$, and by summing the moments of the individual yarns in one repeating section we obtain

$$I_g = 2[7(0.2 + 2.2(3.5)^2 + 0.2 + 2.2(1.5)^2) + 0.2 + 2.2(2.5)^2 + 0.2 + 2.2(0.5)^2] = 481.6$$

and $I_r = 1365.3 - 481.6 = 883.7$.
If a modulus of 10.5×10^6 psi for the glass is used (3) and if it is assumed that the remaining area has a modulus about half way between that of the pure resin and that of a mineral- or glass-filled phenolic molding compound, or approximately 1.6×10^6 psi, then

$$E_1 = \frac{481.6 \times 10.5 \times 10^6}{1365.3} + \frac{883.7 \times 1.6 \times 10^6}{1365.3} = 4.74 \times 10^6 \text{ psi.}$$

By using a strength of 270,000 psi for the heat-cleaned glass (4), a strength of 10,000 psi for the resin, and a formula similar to that used above for the modulus, we find that

$$F_1 I_1 = F_g I_g + F_r I_r$$

F_1 = strength of the laminate =

$$\frac{481.6 \times 270{,}000}{1365.3} + \frac{883.7 \times 10{,}000}{1365.3} = 101{,}700 \text{ psi.}$$

A similar analysis was performed for the other layups and the results are presented in Table I.

In the above analysis several broad assumptions were made (1) the contribution of resin and glass is the same on both the tension and the compression sides of the laminate (2) the contributions of resin and glass to strength properties are additive in nature (3) there is no shift of neutral axis during test (4) stress concentrations, such as incipient failures due to abrupt curvature in fibers at the "one under" weave pattern, are considered negligible.

In spite of these assumptions, however, this method has proven valuable in estimating the strength of laminates in order that the importance of fiber orientation and position to the strength properties may easily be shown.

Conclusions

The symbols used in this paper for representing layups are helpful in visualizing the relative merits of various layup configurations. Position and orientation of glass fibers in thin laminates made with long-shaft-satin-weave cloth may have a marked effect on the flexural properties of the laminates. It has been shown that this effect diminishes and becomes negligible as the number of plies is increased. In some applications, the choice of layup configuration may critically affect part suitability; the use of tracer yarns to facilitate proper layup of cloth would be advantageous in such cases.

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Acknowledgments

The author wishes to thank D. R. Turk and J. A. Sporcic of the Hughes Aircraft Company Research Laboratories for their advice and assistance in the preparation of this paper. ★★

Figure 1. Styrene-Epoxy block molded with colored resin and cross sectioned to show interior foam.

A New Low Density Molding Material

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THERE ARE MANY PLASTIC foams available commercially of both the thermoplastic and thermosetting types. Although these two materials are different in many respects both physically and chemically, the methods of operation used to fabricate them has also served to distinguish between them. The thermosetting foams are generally formed by self expansion of catalyzed resin syrups while simultaneously curing to produce a hardened, expanded structure. On the other hand, all themoplastic foams are available in either the expanded state, in the log of board form, or in the form of a liquid, powder, or beads which require a heat fabrication operation to expand or form them into a final desired shape. Because the thermoplastic materials depend upon an external heat source for their formation, these materials are not considered self-expanding.

Self Expandable Thermoplastic Foams

A new technique has now been developed to produce thermoplastic foams which are capable of self expansion. This technique is based upon formulated mixtures of thermoplastic beads or granules and exothermic curing thermosetting resins. The actual foaming or expansion is accomplished by the exothermic heat produced during the cure of the thermosetting resin. This heat softens and expands the thermoplastic beads or granules which contain a dissolved expandable gas. In moldings produced by this technique, the thermosetting resin forms a hard resin-rich surface on the part and acts as a binder which adheres the expanded granules together. Systems must be chosen to fulfill two main prerequisites to be successful.

1. The thermosetting resin must not chemically attack the thermoplastic granules.

2. The exotherm produced during the cure of the thermosetting resin must be sufficient to soften and expand the gas-containing thermoplastic granules.

This foaming method will work with several polymer systems. In order to illustrate the technique involved and to demonstrate some of the properties obtainable by this technique, this discussion will be limited to a system utilizing epoxide resins and expandable polystyrene beads.

Polystyrene Bead-Epoxy Resin System

The epoxy resins can be used successfully as an exothermic material with expandable polystyrene beads to produce a self-expanding low density molding material. During the molding process the expanding beads force the epoxy resin outward and toward the mold surface. This movement of resin results in a hard resin skin and a network of cured epoxy resin surrounding each individual expanded bead. This resulting structure can be seen in the sectioned molded block in the title figure.

The methods, compositions and products described in this article are the subject of pending applications of The Dow Chemical Company for patents in the United States and principal foreign countries.

This paper was presented at the Thirteenth SPE Technical Conference.

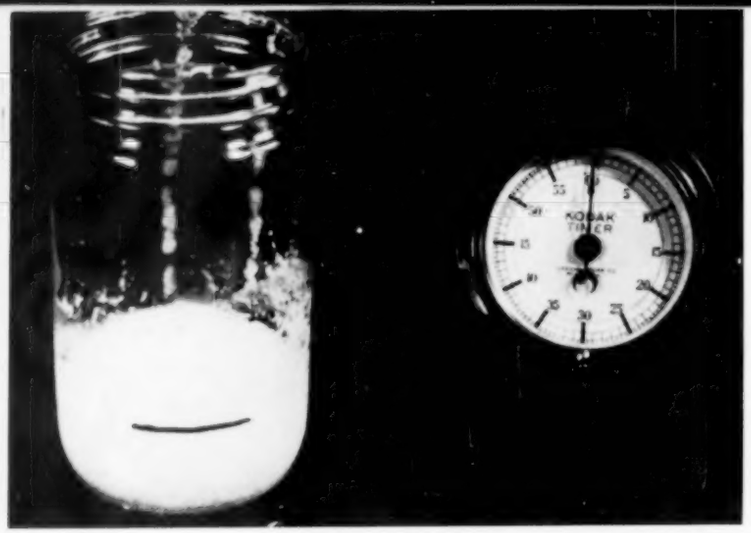


Figure 2. Bottle contains Q-4124.2 immediately after mixing.

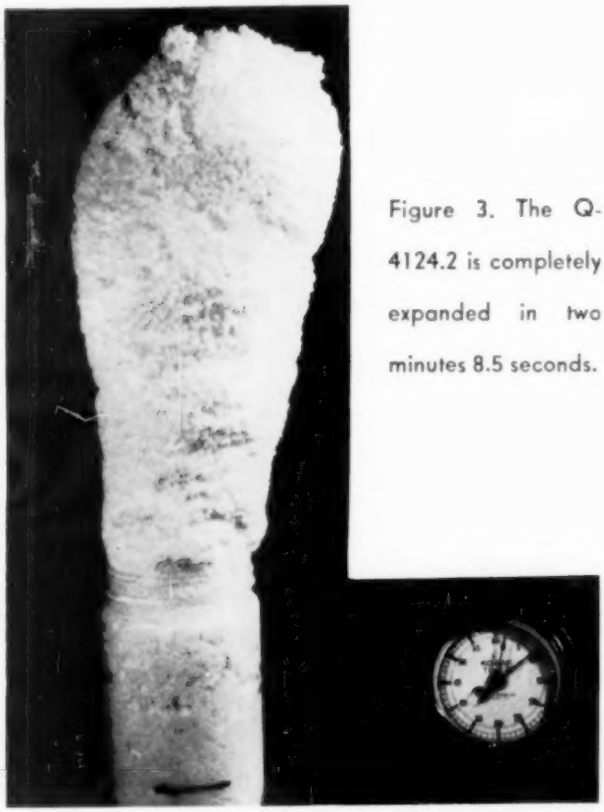


Figure 3. The Q-4124.2 is completely expanded in two minutes 8.5 seconds.

Moldings produced by the new technique have several desirable and unique properties. They can be briefly listed as follows:

1. Expands independently of an external heat source.
2. Moldings are covered with hard, tough skins.
3. Good adhesion to metals, glass, wood, and several plastic surfaces.
4. Structurally strong.
5. Low water absorption.
6. Low thermal conductivity.
7. Freedom from mold shrinkage.
8. Unicellular.
9. Wide density range.

Formulations

The actual molding techniques can be best explained by illustrating a selected formulation of components designated as Dow Experimental Plastic Q-4124.2. This is composed of four components which may be employed in the following proportions:

Component	Parts by Wt.
Exp. Plastic Q-4115.2 Epoxy Resin	100
Exp. Plastic Q-865.2 Expandable polystyrene beads	120
Dow ET-82 Curing Agent	20
Dow ET-225 Modifier	10

The epoxy resin to expandable bead ratio may be varied from 1-1 to 1-2 to obtain a range of densities and physical properties in the finished molding. A resin to bead ratio of less than 1-2 generally will not permit sufficient exotherm to be generated to cause the beads to expand. The best foaming occurs when a 1-1.2 resin to bead ratio is employed. Experimental plastic Q-865.2 Dow expandable beads measuring 1.4 mm. and 2.8 mm. in diameter may be used. Each size may be used individually or in combination to obtain various densities and physical properties. The use of 2.8 mm. Q-865.2 beads generally produces lower densities than the 1.4 mm. beads. Dow ET-82 and Dow ET-225 curing agent, and modifier, are used in an established ratio of 20 and 10 parts respectively per hundred parts of resin. Figures 2 and 3 show the overall foaming volume change, of a Q-4124.2 sample using a ratio of 1 to 1.2 of resin to beads.

Molding Considerations

The four components of this system must be mixed together thoroughly before charging to the mold. The foaming efficiency, which includes completeness of mold filling, general moldability, absence of voids, density, good bonding to surfacing skins, speed of foaming, and overall cycle time, is dependent upon the following variables:

1. Temperature of the reactants.
2. Mass of the reaction mixture.
3. Geometric shape of mold.
4. Temperature of mold.
5. Completeness of mixing.

The reaction time required to produce expansion of the polystyrene beads is dependent upon the initial temperature of the reactants. This time, depending upon the mass of the reaction mixture, can be varied from about 15 minutes to less than one minute. For the most rapid foaming, the epoxy resin may be preheated to 195 F. This also lowers the viscosity of the resin which facilitates easier handling and mixing. When the resin has reached the preheat temperature, the beads are added to the resin and mixed thoroughly to insure proper wetting of the beads by the resin. The curing agent and modifier are then added to the resin-bead mixture and thoroughly blended. The reaction mix should then be charged to the mold, the mold closed, and clamped shut.

Molds must be constructed to withstand the foaming pressures exerted. These pressures developed during the foaming operation are in the range of 10-60 pounds per square inch and are dependent upon the density of the molding. Because the epoxide resins are excellent adhesives, molds used in repeated molding cycles must be provided with coatings of Teflon, silicone, or other commercially available mold release agents to insure proper release.

The density of a given molding is determined by several factors:

1. Mass of charge to mold.
2. Resin temperature.
3. Mold temperature.
4. Type of bead used.
5. Resin to bead ratio.
6. Geometric shape of mold.
7. Surface area to volume ratio.

To obtain optimum expansion, molds should be insulated or heated to reduce the loss of exothermic heat. Coring is desirable to provide an efficient method of heating the molds as well as cooling for optimum moldability and shortest overall cycle time.

Densities of styrene-epoxy moldings are taken to be the weight of a completed part. Due to the resin rich surface and less expanded beads present on the surface of these moldings, there is a density gradient throughout its structure. At the present time, the 1.4 mm. diameter beads have produced minimum densities of 6 to 8 pounds per cubic foot. Beads of 2.8 mm. diameter are capable of reducing this density to 4.5 pounds per cubic foot.

The ability of this material to expand against and adhere to most materials suggests its use as a structural filler in sandwich construction. A sandwich structure can be formed by placing the facing materials at the bottom and top surface of the mold prior to foaming. Rigid materials such as stainless steel, aluminum, galvanized iron, glass, wood, and high impact plastic sheet have all been successfully used in sandwich panels.

Reinforced glass laminated skins can be produced simply by placing dry glass cloth in either or both surfaces of the mold. During the foaming process, the resin is driven to the surface of the mold, thereby saturating the cloth. See Figure 4. This technique looks especially interesting as a method for producing sandwich panels in the construction field. Panels produced by this one step operation have the advantage of being light in weight, are good insulators, and are covered on both sides with a reinforced structural skin.

Sandwiches produced with this new system possess unusual strength characteristics. The core, which has a density gradient throughout its structure possesses an increasing sheer modulus from the center to the surfaces. This is not a linear function, but it is certainly an improvement over a typical sandwich where the core is of uniform density up to the skin. Thus, the stress distribution in structural sandwiches made from Q-4124.2 are more ideally balanced.

When foaming between thin flexible laminating materials, it is important that these surfaces be backed up with retaining molds to prevent distortion. Complex shaped laminating skins should be held against retaining molds securely to prevent distortion. This is particularly important when foaming against thermoplastic skins that could distort from the exothermic temperatures and pressures produced by the reaction mix. The use of vacuum ports in the retaining molds to hold thin surfacing skins tightly against the retaining molds has been successfully employed.

Inserts placed in or projecting into mold cavities can be easily encapsulated by the foam material. Here again the resin is driven to the exposed surface which coats and adheres the part securely in place.

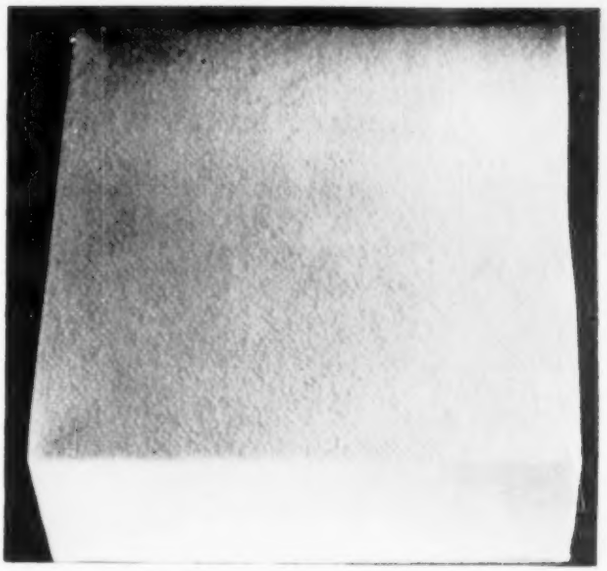


Figure 4. Saturated glass cloth surface produced by the expansion of Q-4124.2.

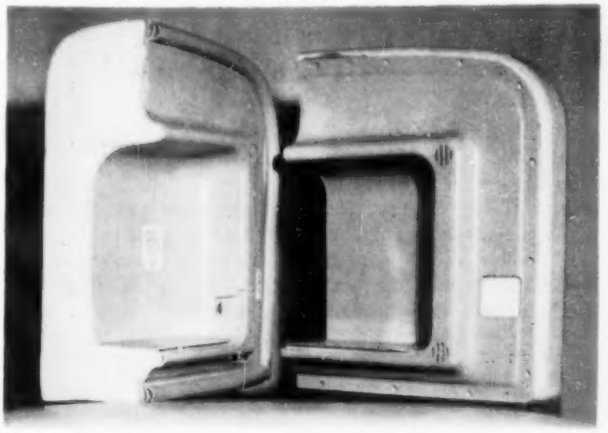


Figure 5. Refrigerator door molded by foaming between molded plastic surfaces.

The unicellular construction, structural strength, and low thermal conductivity value have encouraged the use of this material in refrigeration applications. Several prototypes of refrigeration parts have been made to demonstrate the adaptability of this material for this use. Figure 5 pictures a cross sectional view of an upper half of a refrigerator door produced by expanding in place between molded high impact plastic sheets. The outer and inner door liners, formed prior to foaming, were placed in retaining molds during the molding operation. Doors have been successfully formed with parts such as lock mechanisms, latches, door hinges, gaskets, and fixtures incorporated in the molding during one fabrication step. Doors produced in this manner have proven to be extremely strong and durable and promise to provide a satisfactory method for fabricating a complete plastic refrigerator door.

Physical Property Data

Figure 6

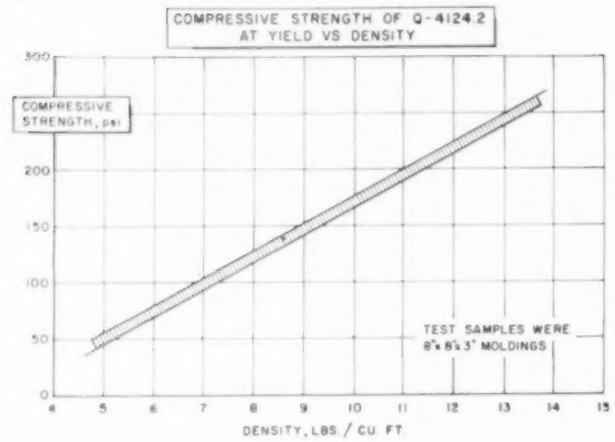


Figure 7

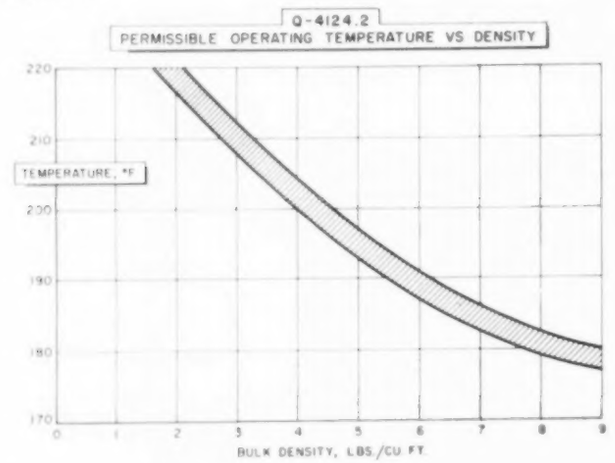
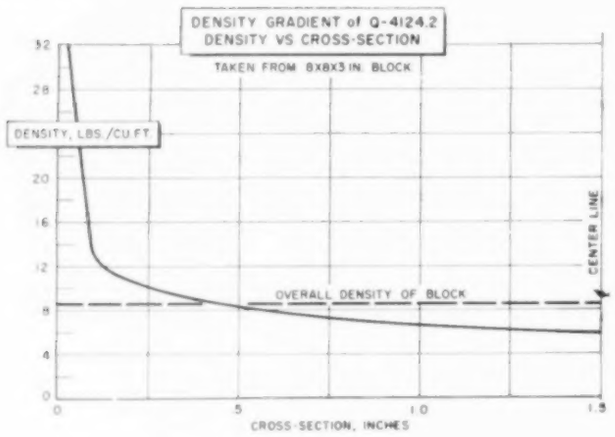


Figure 8



Properties

Properties of Q-4124.2 are a function of density. Some of the more important physical properties are illustrated. Figures 6 and 7 show the compressive strength and permissible operating temperature with respect to density. Figure 8 illustrates the density gradient through the cross section of a typcial molding from the edge to center of a 3-inch block.

The water resistance properties of this material are excellent. The moldings are characterized by their hard epoxy resin surfaces, as well as being composed of millions of tiny non-interconnecting cells. Like other polystyrene type foams, the thermal conductivity of this material is low. The factor has been determined to be in the range of 0.24 BTU's/hr./sq. ft./°F/in. of thickness.

Applications

Applications for this type of material look promising in a number of fields. The general properties as described suggest the following general applications:

1. Low temperature insulation
2. Buoyancy
3. Sandwich construction
4. Structural low density filler
5. Low density molding material

Specific applications in the low temperature insulation field include the use of this material to form refrigerator doors and cabinets, freezer lids, and evaporator doors. Other potential uses include transportation insulation, air conditioning, insulated packaging, and cold storage building panels. Applications as a buoyancy material cover the construction of boats, boat buoys, floats, pontoons, life preservers, water sports equipment, and flotation chambers in marine construction. The ease in fabrication of sandwich construction suggests use in truck body panels, building panels, doors and partitions, boat construction, furniture, and aircraft structures. Many miscellaneous applications such as a reinforcing medium for sheet metal parts, encapsulation of electrical components, anti-corrosive structures and use as a shock absorber in automotive construction are also being considered.

In summary, Q-4124.2 should be considered as a structural molding material, and therefore should not be considered as a replacement for low density non-structural void fillers. Styrene epoxy moldings should find their widest application in products which encompass the advantages and properties offered by its utilization. Furthermore, this system offers a new molding material which should permit fabricators to attain greater design latitude for producing new and better specific end products. ★ ★

14th SPE Conference January 28-31, 1957

Maintenance of . . .

Electrical Equipment

F. R. Cinco

Reed-Prentice Corp.
Worcester, Mass.

. . . best way to avoid repair costs is to prevent the need for repair . . .

A **PREVENTIVE MAINTENANCE PROGRAM** can be defined as one in which equipment is inspected, tested and reconditioned at regular intervals to prevent failure in service and to retard deterioration. A measure of the effectiveness of preventive maintenance is the extent to which emergency repairs have been eliminated. A well planned program foresees and prevents trouble through constant supervision, thereby preventing productive interruptions.

Planned maintenance helps the manufacturer reduce the cost of goods by getting the maximum use from his equipment and by reminding him to make modifications or renewals on a planned rather than a hit-or-miss basis.

Let's compare a planned maintenance system against a hit-or-miss system.

With a planned system, the actual production curve would closely parallel the theoretical maximum production rate of the machine. Compare this now with the hit-or-miss method. No planning for maintenance means down-time is increased due to the unavailability of parts. At no time do you know the condition of the machine or its critical parts.

It can be seen that the results of a preventive maintenance program would be:

1. More production from each machine.
2. More production from smoother work flow.
3. Increased maintenance budget effectiveness.
4. Assurance of safety.

How do you set up a program of planned maintenance? Actually there are many procedures for doing this. Every plant must establish one to suit his own needs, and large electrical manufacturers such as General Electric and Westinghouse will aid anyone in evaluating his program.

The Five Steps

One thing is common to all systems, however, and that is the five steps that must first be accomplished.

1. Gather complete equipment data. Go through your plant, recording nameplate and application data for every piece of electrical apparatus on separate cards.
2. Determine the extent of routine maintenance. Analyze all equipment from the standpoint of importance to operation. Include only those items on which the program will pay dividends.
3. Establish a routine operation control system. Determine the duty performed by each piece of apparatus covered. Arrange the inspection system and frequency according to need and experience.
4. Evaluate for critical maintenance. Set aside a budget to stock the critical renewal parts which minimize costs of down-time.
5. Establish a critical maintenance program. Organize a list of critical equipment.

So much for the means and methods associated with the prevention of breakdowns. Now let's see what should be inspected and what to look for in carrying out this system.

First, let's consider the motor. What are the principal causes of motor failure?

The number one cause of motor failure is dirt or dust. Dirt acts in various ways to destroy the insulation and bearings, to plug the ventilating spaces and reduce the circulation of air. Dirt contains chemicals or abrasives which attack the insulation causing the resistance of the insulation to become less and less. It absorbs oil and water which, in turn sets up conducting paths for short circuits. It fights lubrication and destroys bearings. It causes motors to overheat with the final result of failure. Consequently, the number one and most important rule is to **keep the motor clean.**

Moisture and stray oil are generally found around a plastic machine. These two elements attach themselves to lint, dust, and other foreign material and eventually find their way into the motor air passages attacking the insulation. They will tend to destroy the insulation by softening and saturating, thereby setting up leakage paths for the voltage and the eventual breakdown of insulation.

Proper Lubrication

Another reason is friction through improper lubrication. The proper **type** and the **amount** are very important. The wrong type, insufficient amount, or contaminated oils will allow friction to be produced bringing ruin and destruction to the bearings. Oil is the cheapest item in the operation cost, yet no one thing is more important, nor is there anything more sure to cause trouble than improper lubrication. **Don't guess!** Play it safe. Follow the motor manufacturer's lubrication instructions.

Vibration shakes the life out of a motor. It shakes parts loose, breaks connections, breaks down insulation, causes rapid bearing wear. One of the most common causes of vibration is misalignment, either angular or parallel.

In general, to add years to motor life, follow these few simple rules:

1. Keep it clean.
2. Keep it properly lubricated.
3. Keep a regular inspection schedule.
4. Don't wait for motors to squeal for lack of oil, or smoke from overload, before checking their condition.
5. At all times know the condition of the motor.
6. Know what loads the motor must carry.
7. Correct any indication of weak points before the motor fails.
8. Remember that prevention is better than cure.

Now what about control? To answer this, we should first know what constitutes controls. There are many and varied types, however, all can be listed as follows:

1. Magnet operated devices.
2. Thermally operated devices.
3. Motor operated devices.
4. Static accessories.
5. Mechanically operated devices.
6. Electronic devices.

Control Equipment

As was the case with motors, cleanliness of control equipment is one of the most important factors towards the prevention of breakdowns. Accumulations of dust and dirt should regularly be removed either by vacuum or by blowing with compressed air. This is important, as dust may not only prevent the control devices from operating normally, but also may contain conducting material which will ultimately form a path between points of different potentials, resulting in a short circuit. Dust on the surfaces of interlocks can prevent the circuit from being completed, even when the contacts are closed. In addition to dirt, here are a few other items to inspect for.

Magnet operated devices—Starters, contactors, relays and solenoids.

1. Control circuit voltage. A low voltage condition causes contactors and relays to operate sluggishly. The contact tips may touch but not under complete pressure, causing the contacts to overheat and weld. Over-voltage, on the other hand, shortens coil life and also increases the closing force, causing mechanical wear and bounce.
2. Excess heating of parts as evidenced by discoloration, charred insulation, or odor.
3. Freedom of moving parts (no binding or sticking).
4. Condition of contacts. Every time contacts open or close they are subject to mechanical wear and electrical burning, consequently these items may require considerable maintenance depending upon their operating conditions.
5. Loose connections.
6. Excessive noise in AC magnets.
7. Evidence of dripping water or liquids falling on the control.

Thermal Controls

Thermally operated devices—Overload relays, temperature relays and thermostats.

In addition to the above mentioned items, the following should be checked.

1. Condition of heating element.
2. Condition of control circuit contacts.
3. Check to see that the contacts open when the latching mechanism trips.

Motor operated devices—Times and pyrometers.

1. Operation. This includes proper functioning of the timing devices, and proper sequencing.
2. Excessive vibration or noise when in operation.
3. Wear or roughness of sliding contacts.
4. Condition of gearing, springs, clutches, and lubrication where recommended.

Static accessories—Transformers, fuses, resistors, capacitors, wiring, bus, and cable work.

1. Excessive heating of parts.
2. Corrosion.
3. Loose connections.

Mechanically operated devices—Master switches, drum controllers, push buttons, selector switches, manual starters, limit switches, rheostats, flow switches, pressure switches.

Personnel Protection

These items are most important and should definitely be checked very thoroughly. They form the basis of personnel protection. They are the actuating media of the safety circuits. Remember that human lives are dependent upon the proper operation of emergency buttons, master switches, selector switches, limit switches, pressure switches. Check these items for:

1. Dirt
2. Excessive heating.
3. Freedom of moving parts.
4. Corrosion
5. Contacts and contact pressure.
6. Loose connections.
7. Excessive arcing.

This paper has not dealt with specific problems of electrical maintenance because there are too many and the conditions surrounding their causes are too varied. What we have attempted to point out is the fact that many of the breakdowns can be avoided through a proper periodic simple inspection.

In summarizing we can say that breakdowns due to electrical failure can be minimized if you follow these suggestions.

1. Know your equipment.
2. Establish a preventive maintenance program.
3. Keep the equipment clean. ★ ★

Reference: General Electric Productive Maintenance Forum, Feb. 1955.

Uniform Plastic Stock Temperature Means

Better Injection Molding

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Midland, Michigan

. . . silver streaking, discoloration and brittleness, sink marks, crazing are all troubles that can be helped by heating the molten plastic uniformly throughout. Heating cylinder designs and improvements hold one key to trouble-free molding . . .

THE NEED FOR a uniform plastic stock temperature has long been recognized. Manufacturers of injection molding machines along with manufacturers of plastic molding materials have made much progress in the development of more efficient injection molding machine heating cylinders. The needs for a more uniformly plasticized material before injection into the mold cavity are many.

Problems which have annoyed molders for years may be eliminated or at least minimized with uniformly plasticized molding materials. Certainly this would be a step toward elimination of silver streaking which is annoying and costly because of its persistence in occurring and recurring in the same mold regardless of the amount of work performed toward solving this problem. It is common molding shop knowledge that overheated plastic is a major cause of silver streaking. This does not necessarily apply to the mass average temperature of the plastic but may apply to localized areas in the molten plastic which have become overheated because of too long a contact period with the cylinder walls or heated torpedo surface. As the fluid plastic flows in the cavity, these localized hot spots cannot withstand the pressure exerted by the ram and therefore erupt. This eruption of the normally smooth plastic front as it flows in the mold cavity produces silver streaking.

This paper was presented at the Thirteenth SPE Technical Conference.

Discoloration and brittleness of plastic parts associated with degradation of the polymer would be reduced with uniformly plasticized molding materials. The basic function of the heating cylinder is to convert the solid plastic granules to a molten fluid mass capable of flowing under pressure. To accomplish this the heating cylinder has been equipped with a torpedo which may or may not be internally heated and heater bands extending from the front to the rear of the cylinder. The primary function of the torpedo is to increase the heating surface and to decrease the thickness of the plastic being heated. The heater bands transmit heat directly into the cylinder walls.

The Average Mass Temperature

To arrive at some predetermined mass average temperature of the plastic the cylinder temperatures must necessarily be set at a temperature somewhat higher than the desired mass average temperature. As the mass average temperature requirement rises due to molding needs, there exists the possibility of some portion of the plastic reaching a temperature at which degradation of the polymer occurs. This is due to the spread or deviation from the mass average temperature with some portion of the plastic being below this desired temperature and some portions above. This temperature spread in conventional heating cylinders is considerable and as the desired mass average temperature of the plastic approaches the temperature at which degradation of the

polymer occurs the more likely will be the chance of some discoloration and brittleness of the finished plastic part.

The growth in use of plastics in the packaging and container field during recent months has been tremendous. To be competitive the molder must produce parts at a maximum rate and with a minimum of labor and material. Automation along with thinner section thickness of the finished part has been the technological target for the injection molder entering this field. The success or failure of this automatic operation depends upon closer control of the many variables associated with injection molding. If any one variable cannot be controlled the whole operation becomes a complete failure.

The Need for Uniform Heat

High on the list of variables to be controlled is the plastic temperature. Uniformly plasticized material is extremely important due to thinness of the part and the degree to which the nozzle temperature must be controlled. Any cold slug present in the fluid plastic could easily plug the nozzle or cause unbalanced flow of the plastic within the cavity producing short shots or trapping air in the side of the part. To be successful in the molding of thin section containers, the mold cavity must be filled extremely fast. This is due primarily to the plastic skin formed next to the cavity walls during filling. The flow in the cavity becomes dependent upon the thickness between the solidified skins and not upon the thickness of the cavity. To accomplish high speed injection an injection molding machine capable of high injection speed becomes a necessity. Of equal importance is uniform plastic stock temperature to assure easy filling and a reliable, uniform cycle. If the continuity of the molding sequence is interrupted for any reason, the press must be stopped, the trouble located and then started again. This can be very costly and time consuming for the molder.

Nonuniform plastic stock temperatures produce parts which do not shrink uniformly thereby causing localized stresses and a tendency to warp. Other defects arising from nonuniformly plasticized molding material are sink marks, poor or obvious weld lines, silver streaking, bubbles, brittleness, crazing, surface ripples, short shots and low heat distortion temperatures.

Developments in Heating Cylinder Design

Work has been done in conjunction with many of the injection molding machine manufacturers to develop a method for rating the efficiency of heating cylinders (1). The efficiency has been described as the ratio of the actual amount of heat absorbed by the plastic to the theoretical or maximum amount which could possibly be absorbed. This value varies considerably as the output in pounds per hour changes. The heating efficiency can be measured at several different throughput rates and a graph of heating efficiency versus output rate can be drawn. A standard rated efficiency of eighty percent has been chosen as the point of cylinder rating and for comparison of one cylinder design to another. It was also determined that the output of any heating cylinder equals a constant times the heating surface squared to plastic volume ratio.

With the use of a thermocouple located in the nozzle, the plastic temperature was found to vary considerably from one point of measurement to another. One factor affecting the plastic temperature was torpedo design. From this work it was determined the heating cylinder should have the following qualities:

A. The chamber should have adequate plasticizing capacity. This means the ability to produce uniformly heated plastic at well above the maximum production capacity of the machine.

B. This plasticization should result in a minimum of pressure loss.

C. The construction of the chamber should be leakproof and strong, yet it should be demountable for easy cleaning.

D. The flow path through the chamber should be smooth, with no dead spots. The surfaces should be uniformly heated to assure fast plasticizing without overheating.

Experimental Heater Designs

Many attempts have been made to construct a heating cylinder possessing as many desirable characteristics as possible. Some designs have greatly increased the efficiency of the heating cylinder while others have not been as successful. One design increased the torpedo diameter without increasing the cylinder diameter. This effectively reduced the volume of plastic being heated between the torpedo and cylinder wall. In theory this should have increased the heater efficiency but in actual practice the pressure loss was so great the design was impracticable.

The torpedo length in one design was increased to obtain more heating surface area. The thickness of plastic being heated between the torpedo and cylinder wall remained the same. Here again the efficiency of the heating cylinder should have been increased but excessive pressure loss also made this design impracticable. In any design to increase the heating surface area or reduce the plastic volume being heated excessive pressure loss must be avoided so sufficient pressure remains to do a satisfactory molding job.

More Successful Heaters

Many other designs have been more successful than those just discussed. To increase the effective heating surface more fins have been designed into the torpedo. This increase in the number of fins has been to increase the surface contact area between the torpedo and cylinder wall so additional heat can more readily be conducted to the torpedo. This same goal has also been achieved by increasing the length of the fins without increasing their number, and by the use of a flange arrangement between the torpedo and cylinder wall. Still another method to increase the effective heating surface is the installation of heaters within the torpedo.

During one standard rating test which employed the eighty percent efficiency factor the use of internal torpedo heat increased the rating from forty pounds per hour to seventy pounds per hour (1). This seventy-five percent increase in output rate is considerable. Increased heating surface is also accomplished by greatly increasing the diameter of the heating cylinder in the torpedo area. Here the torpedo diameter has also been increased so the heating surface to plastic volume ratio is as large as possible and yet keeping the pressure loss in this area as low as possible.

For maximum heat transfer from the heater bands to the cylinder wall a close fit between the two should be made. As the cylinder is heated these bands sometime become loose and must be tightened. A small gap

in many instances is a necessity in order to keep the proper tension on the band so the close fit can be maintained. It has been found the method of installing these bands is very important to avoid cold channels of plastic flow within the cylinder. The small gaps between the ends of the bands should be staggered since no heat is produced in these areas. A more uniform plastic stock temperature is possible with this arrangement.

Reflective Shields

Reflective shields around the entire heating cylinder are a great aid in maintaining uniform plastic stock temperatures. This can be explained in the following manner. The heating bands on the cylinder are spaced at certain intervals. This spacing varies with the different machines. No heat is suppled to the cylinder in these spaces between the heater bands. Even the heater bands may not produce uniform heat over the entire width. This in effect increases the area of the cylinder not receiving heat along with the area not covered by heating bands. There are, therefore, areas along the cylinder length receiving no heat while other areas re-receive a concentrated heat input.

Shields are incorporated into the design of many heating bands. This has been very beneficial in reflecting the heat normally lost, back to the cylinder. However, the spaces between the bands remain unchanged. A reflective shield around the entire cylinder is very effective in reflecting the heat back along the entire length of the cylinder.

Thermocouple location is important so the correct cylinder temperature is recorded (2). Since heat naturally tends to rise it has been found that thermocouples frequently read 20° F. to 30° F. lower when located in the bottom of the cylinder than when located on top. This added 20° F to 30° F of excess heat on the top of the cylinder is sufficient to cause degradation of some thermoplastics. We believe the best location for thermocouples is on top of the cylinder. In conjunction with thermocouple location it is becoming more evident injection molding heating cylinders should have at least three zone controlled heating. With anything less than three controlled zones it is very difficult to determine the true temperature of much of the heating cylinder. Any number of the problems of injection molding may arise without positive control of the heat supplied to the entire length of the cylinder.

Recent Heating Cylinder Design

Melt extraction heating of thermoplastics shows much promise of providing a uniform plastic stock temperature for injection molding (3). Melt extraction is a term which has been employed to describe a technique of heating the plastic in a thin layer next to the heating cylinder wall and skimming it off so the next deeper layer of plastic can come into contact with the heating surface. This method essentially eliminates the need to transfer heat through the plastic to melt the entire mass. The heater inherently produces uniform temperature distribution in the plastic since the means of removing the plastic from the heated surface restricts the material removed to that which is well melted. The plastic flows through the many small perforations in the cylinder wall and then through the grooves to the nozzle.

Figures 1 and 2 illustrate two melt extraction heating cylinders which have had considerable success in operation under molding plant production conditions. The Polyliner, (Figure 1), described by duPont engineers (4)

Figure 1. The Polyliner Melt Extraction Heating Cylinder.

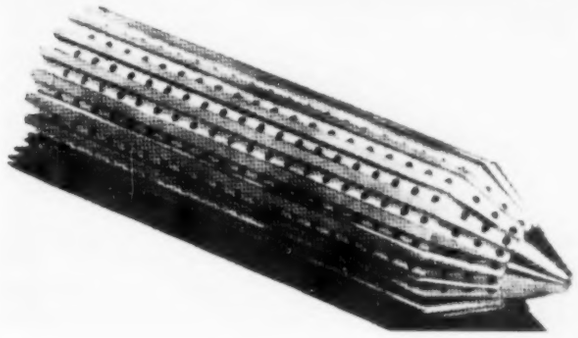
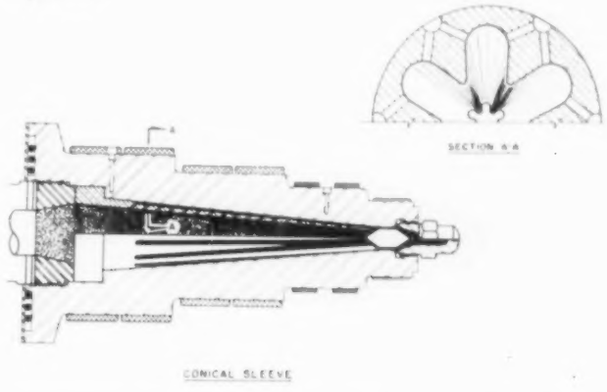


Figure 2. The Maccaferri Melt Extraction Heating Cylinder.



is relatively simple to manufacture, while the Maccaferri liner (5) (Figure 2), has greater area of heating surface for a given size.

When the injection plunger exerts pressure on the granules, the fluid materials next to the heater wall easily flows through the holes into the longitudinal grooves and through the nozzle. As the fluid material escapes, stiffer, less well melted material moves toward the heater wall. Evantually, the plastic next to the wall is too stiff to flow through the holes under the available injection pressure.

Calculations for heating polystyrene are of interest. If the heater wall is at 500° F., polystyrene will be heated to 450° F. in the following time-thickness relationship:

Layer Thickness, Inch	Time, Seconds
.031	3.6
.062	14.0
.250	230.0
.500	921.0

It is not very practical to extract a layer of polystyrene much more than .062" thick because of the long time required to make it sufficiently fluid by conduction of heat through the plastic. On the other hand, layers thinner than .031" can be extracted every three seconds or less.

Melt extraction heaters should have sufficient heating surface to provide the required volume of melted

plastics from a layer about .062" thick to fill the mold in the desired cycle time. Otherwise, the cycle time becomes impossibly long. Melt extraction heaters should depend as little as possible upon heat conduction through the plastic because they cannot allow very much insufficiently heated material to pass through.

Melt Extraction Heaters

The principles and limitations of melt extraction heaters indicate they should be excellent for use in preplasticizing systems. Small amounts of fluid plastic can be skimmed off during very short heating time cycles of two or three seconds each. These small shots can be accumulated and dumped into an injection cylinder quickly to provide large quantities of uniformly plasticized material for injection into a mold which may require thirty to sixty seconds for its cycle because of large size or cooling needs.

Melt extraction heaters permit the use of lower mass average temperatures of the plastic than with conventional heating cylinders employing a torpedo. These lower temperatures are possible because of the greater amount of ram pressure available to force the more viscous polymer into the mold activity. The more uniform plastic temperature, producing a more narrow range between minimum and maximum temperature, allows the use of lower mass average temperatures, without the possibility of some unmelted particles being forced into the cavity.

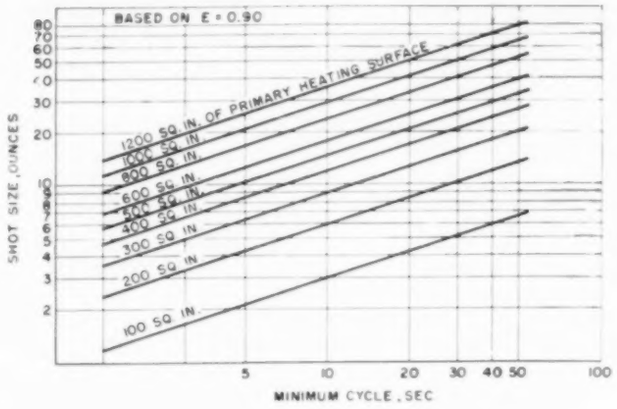
Lower cylinder temperatures will contribute toward shorter cycles and stronger parts. The time required to heat the polymer is reduced and the time for the molded part to solidify so it may be ejected from the mold is also reduced. Tests have shown the lower cylinder temperatures produce parts with better physical properties. Of course, good molding practices dictate how far the cylinder temperatures can be lowered and still produce good parts. No molder will want to mold with the cylinder temperatures so low the polymer is too viscous, thereby producing parts which are highly stressed.

Melt extraction heaters have two other possibly advantageous characteristics. The granules in the central core of plastic inside the heater do not melt. They appear to work their way radially to the heater wall. They do not become hot enough to stick together in the core and they leave room for the air between granules to pass back through the porous mass and escape around the plunger. This is a plus factor in eliminating silver streaking on polystyrene moldings and in reducing oxidation of polyethylene inside the heating cylinder.

Pressure Variation

When the column of granules ahead of the injection plunger is long, as in a conventional heating cylinder, the variation of injection pressure in the mold can be large. The longer the granular zone, the greater the pressure variation because of the compressible nature of the granule column. A superficial examination of a melt extraction heater shows there is a column of unmelted granules which extends the entire length of the heater from plunger to nozzle. Since the plastic moves radially rather than longtitudinally, however, the effective granule column length is approximately equal to the radius of the inside of the heater and is therefore shorter than the column in a conventional heater. Thus, the great length of unmelted granules should not interfere with pressure control in the mold. Observations have shown this is true in heaters which have been in operation.

Figure 3. Performance chart for the Maccaferri Cylinder.



A study of previous work reported shows material would scarcely pass through the melt extraction heating cylinders if the heating efficiency was less than ninety percent (5). The curves shown in Figure 3 indicate heating efficiencies of ninety percent and more when operating at the maximum pounds per hour output. A greater output could not be obtained because the material would not pass through the holes in the liner.

Recent Experience

Recent experience in molding thin wall containers indicates greater uniformity of plastic temperature may be required than that suggested by the standard rating system for heating cylinder designs. Originally the eighty percent heating efficiency figure was selected on a basis of average performance in molding plants. The wall thicknesses then being molded were in the neighborhood of .065" and up. Very few parts thinner than .045" were encountered. Present wall sections call for .045" and less down to as low as .012" in polystyrene containers for single use applications. High injection speed has been recognized as necessary for filling these thin walls. Uniform plastic stock temperatures are also required. Current experiences indicate plastics are being overheated in some cases in order to fill walls as thin as .030". ★ ★

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High Humidity Insulation Resistance of Epoxy Resin Systems

Harvey L. Parry, James E. Carey and M. D. Anderson
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. . . addition of filler to a good epoxy resin impairs insulating properties . . . just how much depends on filler, resin and environment . . .

In a continuation of a study on the effect of fillers on epoxy resin systems (1,2) exploratory experiments have been made on the effect of various types of fillers on insulation resistance at high humidity.

It is well known that the insulation resistance of epoxy resin systems under standard laboratory conditions of 25°C and 50% relative humidity is so good that sizeable amounts of other materials may be added to the system without degrading the product to the point of uselessness. However, when such systems are given prolonged exposure to high humidity, performance is often unsatisfactory. The ability of moisture to wick along the resin-filler interface under some conditions has been reported (3). The intensifying effect that fillers have on galvanic degradation under high humidity has also been reported (4). Hence, one of the components of a resin system whose action at high humidity would be most suspect is the filler.

This paper reports the results of a preliminary study of the problem. It is intended to show the type of effects that result from the use of fillers and the magnitude of these effects. A similar study is planned on the effect of formulation variables on insulation resistance at high temperatures.

Experimental

Insulation resistance was measured according to ASTM D257-54T using the specimen illustrated in Figure 3 of the method. A General Radio Type 544B megohm bridge was used to measure resistance at 500 volts d.c. The environmental conditions of 95% RH at 140°F were selected following information from Bell Telephone Laboratories (5) that they had found these conditions to be very effective in evaluating plastic insulation. The specimens were maintained in this environment by suspending them over a saturated K_2SO_4 solution in a Mason jar from binding posts mounted in a polymethylmethacrylate cap. The jars were maintained in a forced draft oven at 140 ± 1.5°F. Each jar was connected by PVC-covered wire to a terminal strip mounted outside the oven. All specimens were washed well with soapy water, then rinsed with distilled water prior to being put into test.

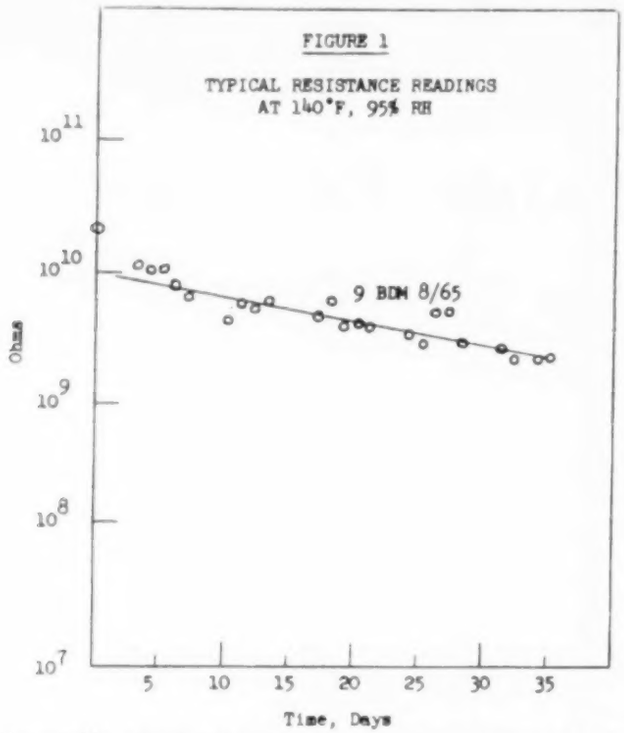
Using this set-up, it was possible to make periodic measurements without disturbing the environment by connecting the bridge to the appropriate terminals outside the oven. The insulation resistance of each specimen was measured daily for a period of 35 days.

Two types of specimens were used in this study, unfilled cast sheet and heavily filled molded sheet.

The unfilled cast specimens were prepared between sheets of plate glass coated with a silicone mold release. Curing was done in a forced draft oven. The resin used was Epon ®828, a typical low molecular weight bisphenol A-epichlorohydrin condensate. The details regarding composition and cure are given in Table I. The insulation resistance vs. exposure time data are presented in Figure 2.

Filled specimens were molded under pressure in order that high filler loadings could be used. Since all filled specimens were based on Epon 828 cured with m-phenylenediamine, a B-stage technique was used to make the molding easier. The m-phenylenediamine was melted and

This paper was presented at the New England SPE Regional Technical Conference.



thoroughly mixed with warmed resin. Acetone was added to reduce viscosity, the filler was stirred in and the resulting paste milled on a two-roll mill at 90°C to remove the acetone and advance the cure to the B-stage. No internal lubricants or release agents were added to the formulation. The ground powder was compression molded in a silicone lubricated chrome-plated mold into ⅛" x 4" diameter discs from which the test specimens were cut. The details of composition and cure are given in Table II and the resistance data in Figure 3.

To apply the Volan finish to the mica and cellulose floc, they were suspended with rapid stirring in a 2% aqueous solution of methacrylato-chromic chloride (Volan-duPont) and the solution gradually neutralized to colorless with dilute NH_4OH. The filler was then washed three times in distilled water and dried to constant weight at 110°C.

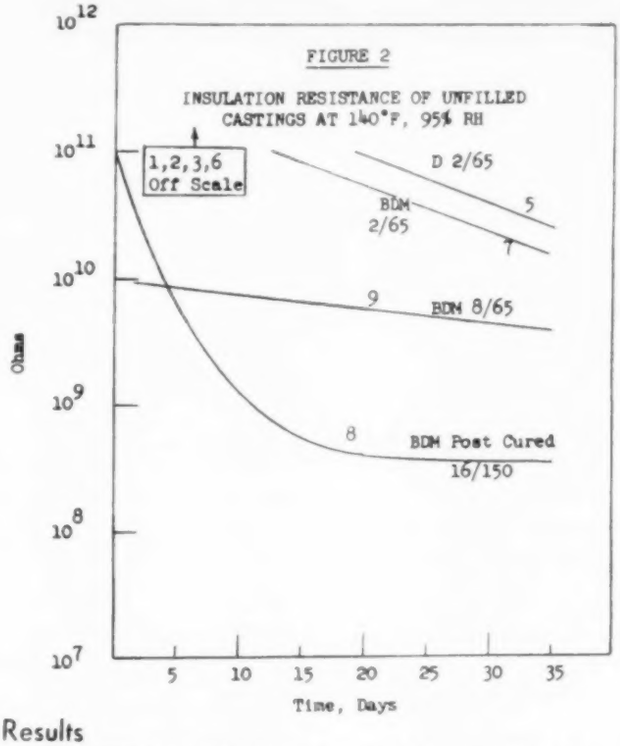
Table I
Composition and Cure of Unfilled Epon 828 Castings

Experiment No.	Concentration (Phr)	Curing Agent	Cure (Hrs./°C)	
1	MPD	12	2/100	+ 16/150
2	"	14	"	"
3	"	16	"	"
5	D	10.5	2/65	"
6	"	"	2/65	+ 16/150
7	BDM	7.5	2/65	
8	"	"	2/65	+ 16/150
9	"	"	8/65	

MPD = m-phenylenediamine, Antara Div., General Aniline & Film Corp.

D = curing agent D, Shell Chemical Corp.

BDM = benzyldimethylamine, Sumner Chemical Corp.



Results

The results obtained are presented in graphical form in the figures that follow.

It became apparent early in the investigation that resistance values greater than 10^{11} ohms were of questionable accuracy; therefore, no curves are given for systems in this range. The observed insulation resistances at various times for a typical specimen are shown in Figure 1. While the scatter of the points indicates that even in the lower ranges the test is not highly reproducible, it is felt that the reproducibility is more than adequate for an exploratory type of program. Data for the remaining specimens are given as eye-averaged curves. The number by each curve corresponds to the sample numbers in Tables I and II.

The initial phase of the investigation dealt with the selection of a resin-curing agent system. Practical considerations limited the choice of curing agents to those with considerable pot life. Three such systems were chosen, and Figure 2 shows the performance of unfilled Epon 828 castings made with these curing agents. Reference to Figure 2 shows that the Epon 828/m-phenylenediamine copolymer at all cures and concentrations studied had a resistance of greater than 10^{11} ohms after 35 days' conditioning. The Curing Agent D catalyzed Epon 828

Table II
Composition and Cure of Filled Epon 828 Moldings

Experiment No.	Filler	Cure (Min./°C)	Pressure (Psi)
10	Water ground mica	10/138	1300
11	Volan A treated w.g. mica	15/132	1200
12	Volan A treated alpha cellulose floc	10/140	1200
13	Chopped glass fibers fired at 900°F	10/127	3200
14	Shredded 181-Volan A cloth	10/130	630

homopolymer when post cured also remained above 10^{11} ohms. For reasons not known, the Epon 828 homopolymer produced by the catalytic action of benzyldimethylamine was markedly inferior and (unlike the Curing Agent D product) got worse with post curing.

One possible reason for this discrepancy is the presumably smaller polymer molecules produced by the BDM since it, at 7.5 phr, is present in higher mole ratio than Curing Agent D at 10.5 phr.

The good performance of the cast epoxy resin cured with m-phenylenediamine and its adaptability to various fabrication techniques led to its use in further work.

Filled Resin Systems

Figure 3 presents the insulation resistance results obtained on exposure of the filled resin systems described in Table II. The control of unfilled Epon 828/m-phenylenediamine is not shown since all values were above 10^{11} ohms.

The best performance was obtained from the Volan-treated glass. It would appear that this filler gives a product whose performance is excellent. It is true that the addition of the glass decreased the resistance over that of the unfilled resin; however, other factors involved in the use of epoxy resins as electrical insulating material dictate that some filler must be used.

The next best results were obtained with the Volan-treated mica. This system, though significantly inferior to the Volan-treated glass system, would still be considered an acceptable system for most applications where high humidity is involved.

The untreated mica is measurably inferior to the Volan-treated mica and would probably be considered as marginally acceptable.

The dismal performance of the other two systems is quite significant. It would appear that the Volan treatment has a tremendous effect on the resin-glass interface but little effect on the resin-cellulose interface.

To place the performance of these systems in the proper perspective, Figure 4 gives the results obtained on a typical alkyd molding powder and a typical mineral filled phenolic molding powder.

Conclusions

The addition of filler to a good epoxy resin polymer unquestionably impairs the performance of the system as an insulator under high humidity conditions; however, there are wide differences between fillers.

The improvement in performance that in some cases results from the use of surface finishes would make it appear that this field is worthy of further investigation.

It is our plan to continue this work in two directions: (1) The insulation resistance of filled and unfilled epoxy resin systems at temperatures above 100°C; (2) The high humidity insulation resistance of filled systems to alternating current. It is felt that an a.c. field will intensify interfacial polarization effects. These data will probably be obtained by dissipation factor measurements at 140°F, 95% relative humidity. ★★

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5. Private communication from Mr. George Deeg.

FIGURE 3

INSULATION RESISTANCE OF FILLED MOLDINGS AT 140°F, 95% RH

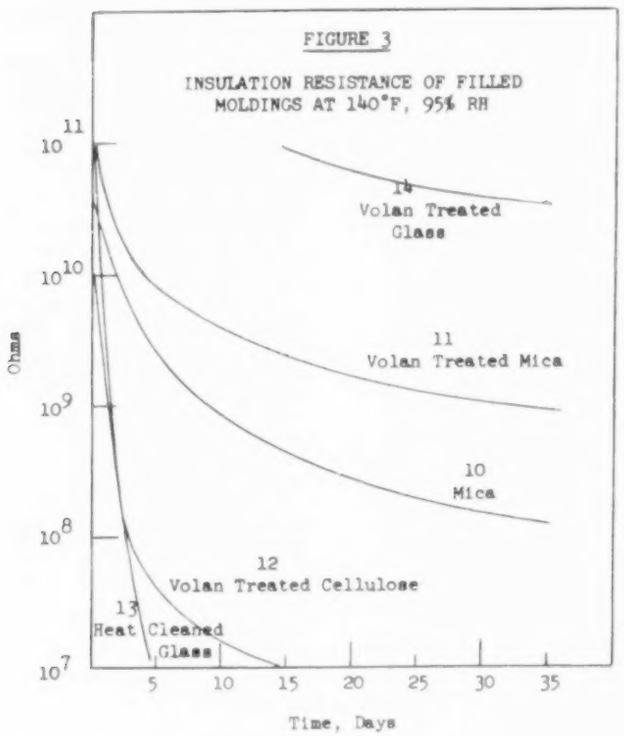
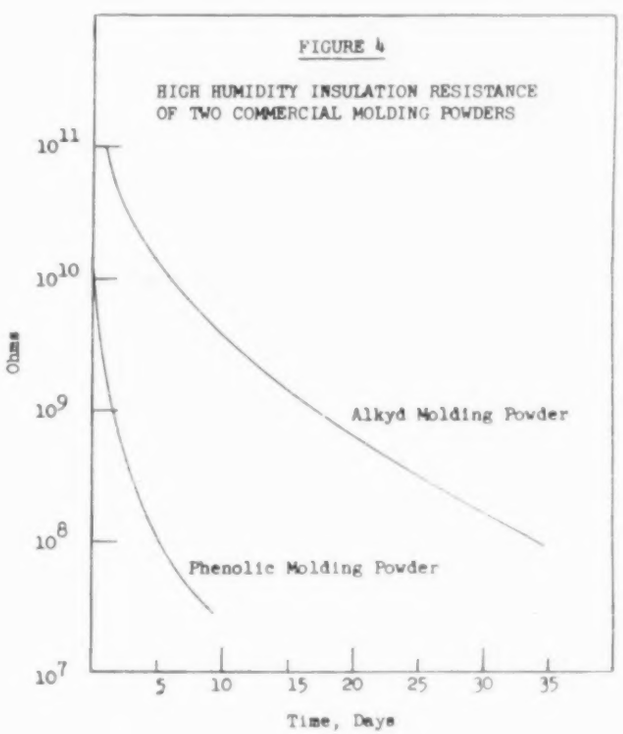


FIGURE 4

HIGH HUMIDITY INSULATION RESISTANCE OF TWO COMMERCIAL MOLDING POWDERS



Treatment of · · ·

Mold Design Problems

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PROGRESS in use requirements of molded articles represents a tremendous growth which is moving so rapidly no one is able to keep current except in his own small field of specialization. This growth is in several directions at the same time and it is substantial.

A growing tendency has been observed with regard to delivering the maximum degree of inherent engineering properties to the end user. In the thermoplastic field the critical elongation of polystyrene has been determined for a number of reagents and it has been found molding operations can do much to deliver the maximum inherent elongation to the end user. It has been found necessary to take steps to prevent oxidation of polyethylene during injection molding and extrusion processes in order to provide the best properties of this material to the end user.

New Emphasis

Many factors which are not new must be given new emphasis in designing today's molds. Progress in the use requirements, plastics materials and molding machinery developments in competition have combined to demand these mold design factors be given a position of dominance which they have not usually had up to the present time.

Molds have always needed to be extremely rigid to provide precision and long life operating characteristics. The growing use of thin wall moldings and the demand for greater dimensional accuracy have caused rigidity requirements to become truly dominant and they must not be ignored or by-passed in these application needs.

It is necessary to be sure every injection mold has mold temperature control means incorporated in its design. It is not possible to mold without being able to control the temperature of the mold accurately everywhere in the mold. Many mold designers have omitted to put water lines where they are needed and

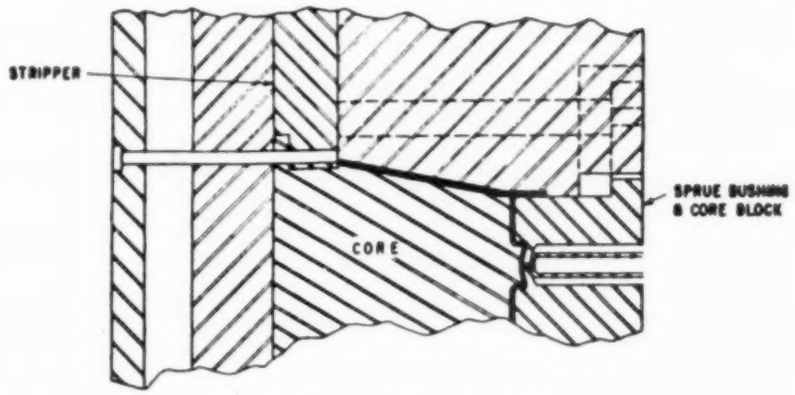


Figure 1. The Double Draw Problem Solution (mold closed)

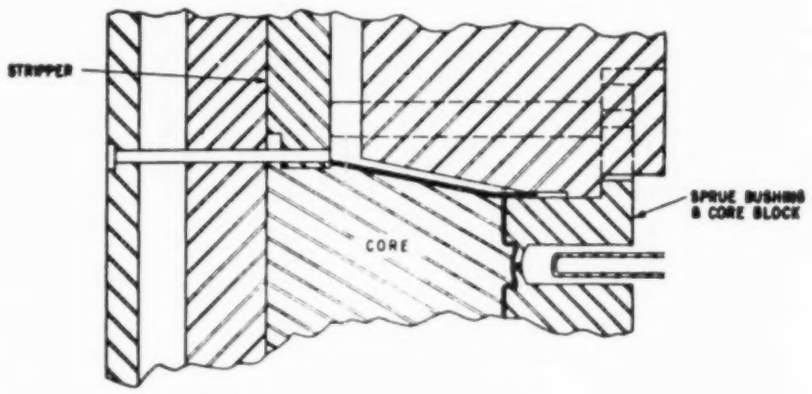


Figure 2. The Mold partly opened

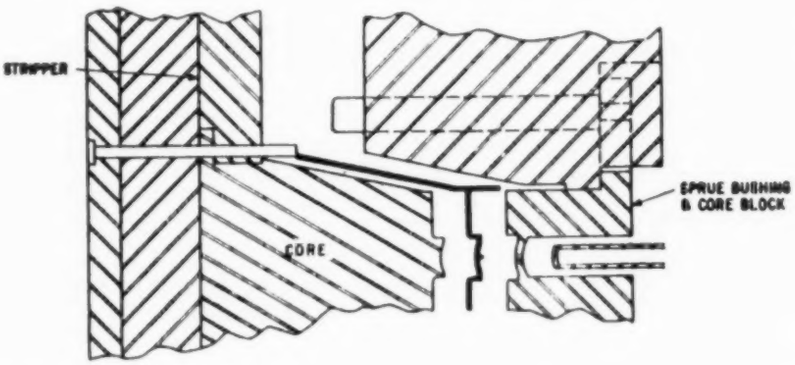
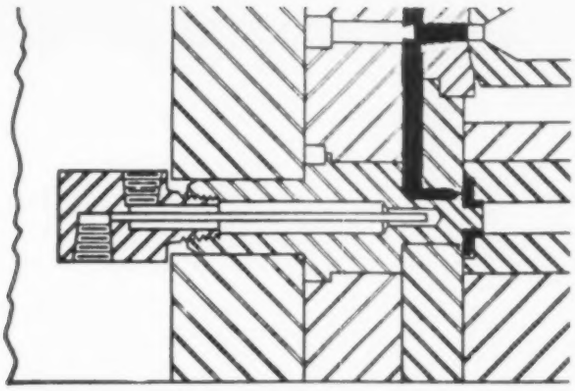


Figure 3. The Mold fully open



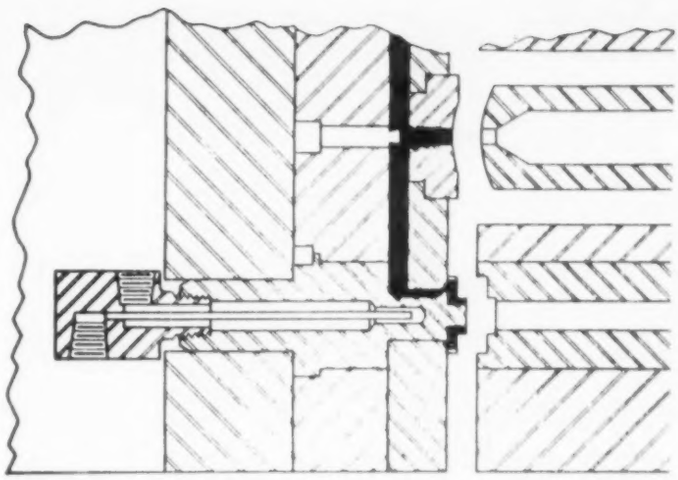


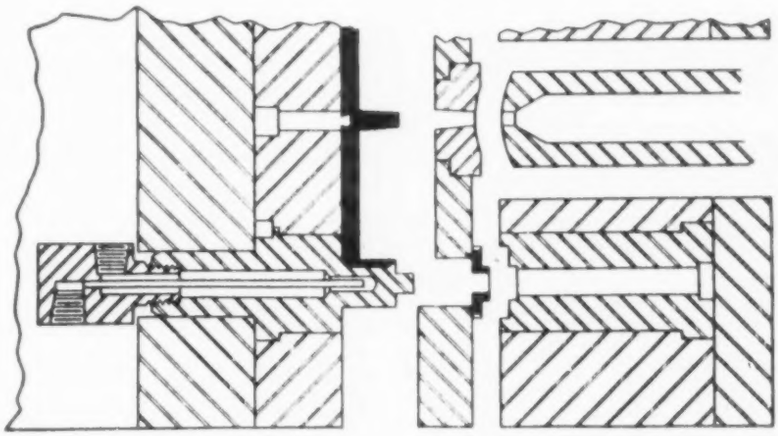
Figure 4. (above) The self-trimming mold closed.
Figure 5. (above right) The same mold open at cavity parting.
Figure 6. (right below) The self-trimming mold, gate-sheared.

have omitted to design several different water circuits in the interest of economy or because it is too difficult to arrange the lines or because the mold is needed so quickly there is not time to determine where to put the lines. This is all false economy and it always results in delayed production and a continuous loss of production efficiency.

Dependability

It is necessary to design dependability in the injection molds of today. These molds are likely to be more complex and have more moving parts. The mold must be protected from damage and the operator must be considered carefully from the standpoint of safety.

The mold designer needs to let the behavior of the plastic and the end use requirements be factors as strong as the mold fabrication problems. He must not be misled into following books and traditions of how molds are made because many molds have been made which do not consider the nature of the plastic and of the task which the mold is to perform. Molds should be designed to do what we wish to have them do rather than to be like some other mold which has been said to be satisfactory according to rumors in the industry.



Some Solutions

Most engineers know a number of old problems which have never been solved satisfactorily. A few examples of such problems and some suggested solutions are illustrated in the figures.

Figure 7. Double Acting Ejector Mold (closed)

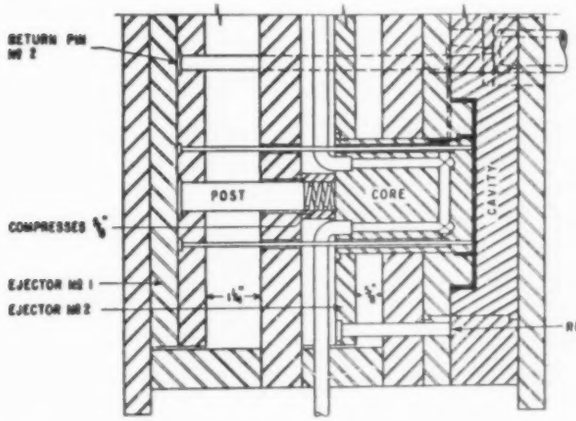


Figure 8. Double Acting Ejector Mold (completion of first action)

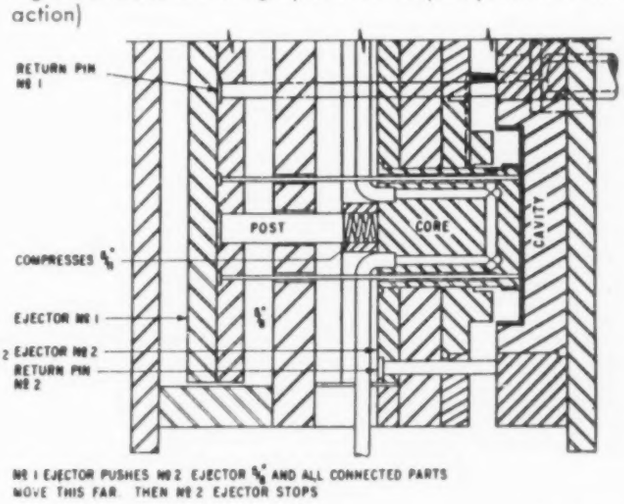
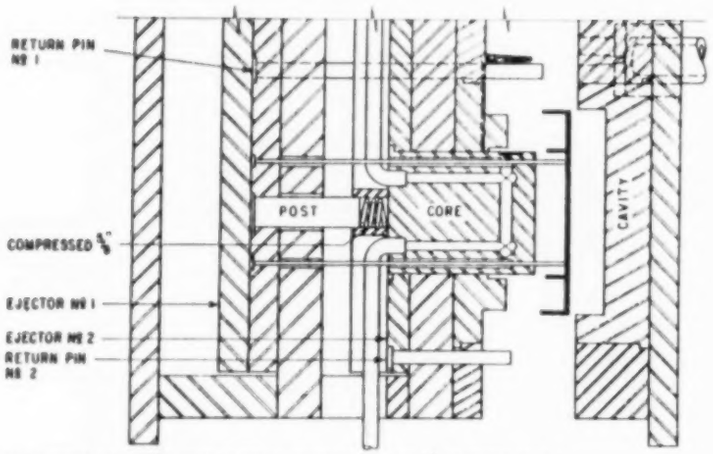

RETURN PIN Nº 1
POST
CORE
CAVITY
COMPRESSES
EJECTOR Nº 1
EJECTOR Nº 2
RETURN PIN Nº 2
Nº 1 EJECTOR PUSHES Nº 2 EJECTOR AND ALL CONNECTED PARTS MOVE THIS FAR. THEN Nº 2 EJECTOR STOPS

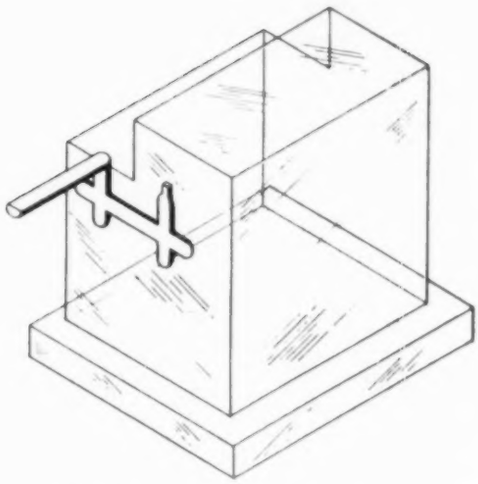
Figure 9.

DOUBLE ACTING EJECTOR MOLD
(COMPLETION OF SECOND ACTION)



NO 1 EJECTOR MOVES ⅛" FUTHER AS SPRING COMPRESSES. LAST ⅛" MOVEMENT OF NO 1 EJECTOR PUSHES BOX FROM CORE SLIDE AND SHEARS GATE

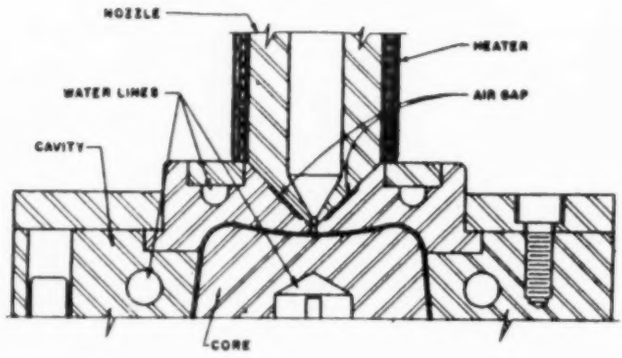
Figure 10.



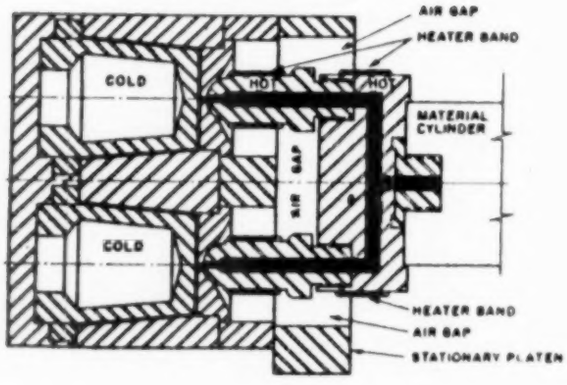
DETAIL OF GATE SYSTEM
IN CORE SLIDE

Figure 11.

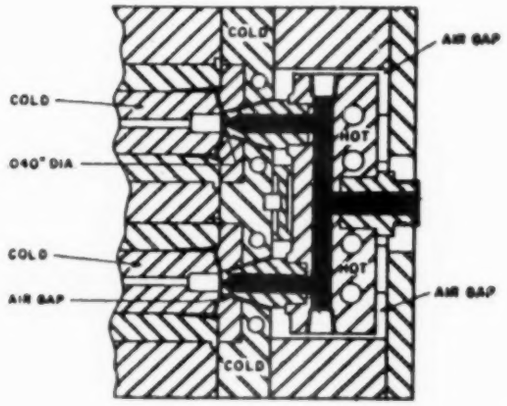
EXTENDED NOZZLE FOR SINGLE
CAVITY AUTOMATIC MOLD



MULTIPLE NOZZLE MANIFOLD



MANIFOLD HOT RUNNER



solidified but not cooled. The plastic is extremely weak and generally the ejection force required to overcome the friction on both sides of the piece is greater than the tensile strength of the material. This is why the plastic breaks off in the mold when it is trapped between both walls and attempts are made to eject it past both walls at the same time.

Solution

Figures 1, 2, and 3 illustrate a suggested method for solving this problem. In Figure 1 the mold is shown in the closed position with a ring of plastic trapped on the injection side of the mold. The sprue bushing—core block is movable and when the mold starts to open as shown in Figure 2, the molded part remains on the sprue bushing until it has moved out of the cavity where it is trapped between both walls on the mold. This operation results in requiring the plastic to slide past the mold wall only on one side of the wall. As the mold continues to open as shown in Figure 3, the piece is pulled from the sprue bushing due to the greater friction of the main core and then the ejector pins push it from the main core in conventional fashion.

Automatic gate shearing of unconventional design is shown in Figures 4, 5, and 6 which illustrate a three plate mold with the sprue bushing in the stripper plate. The runner system is placed between the stripper plate and the core retainer plate. The parts are ejected on the nozzle side of the mold. The runner in this case is a groove cut in the core pin as may be seen in the illustrations. When the mold opens as in Figure 5, the pieces are withdrawn from the cavities and when the stripper plate pushes them off, it shears the gates and leaves the runner and sprue system to be removed. The principal advantage of this mold is an automatic gate shearing arrangement without employing a double acting ejector system.

Double Acting

A double acting ejector system may be used for gate shearing as shown in Figures 7, 8, 9, and 10. This mold design suggestion has two other features which are worthy of note. The part is a small box which has two dividers laterally inside. These dividers would be caught between both walls of the mold in a conventional design. This design, however, has a movable core which is shown in Figure 10. This core slides forward on ejection as shown in Figure 8, while the piece is pushed off the main part of the core by ejector No. 2. Ejector No. 1 continues to move forward as shown in Figure 9 as it compresses the springs between it and ejector No. 2. Ejector No. 1 contains the small diameter knockout pins which push the piece off the movable core section.

This mold design shows a gate which is fed by runners in the core. As the core moves out the runner section is cleared for removal and this type of runner is easily sheared during the ejection operation.

Figure 11 shows three schemes of employing extended nozzles which gate directly into the mold through a pinpoint gate without a runner. The central upper view shows the detail of the sprue bushing and cavity bottom combined and the left and right hand lower views show other arrangements of this system in multiple cavity molds.

Another of the perennial mold design and operation problems involves slender core pins which become extremely hot during normal operation because they are not usually considered to be easy to cool. Figure 12 shows an arrangement for cooling a core which may be approximately 3/8" diameter or smaller. The base of the core pin is made large to provide a water chamber and water inlets and outlets are shown in the illustration. A central baffle is fastened to a pipe plug which screws into the bottom of the water chamber. This type of cooling operates satisfactorily for fairly large cores when the hole for the

(Please turn to Page 69)

Figure 12. An arrangement for core cooling.

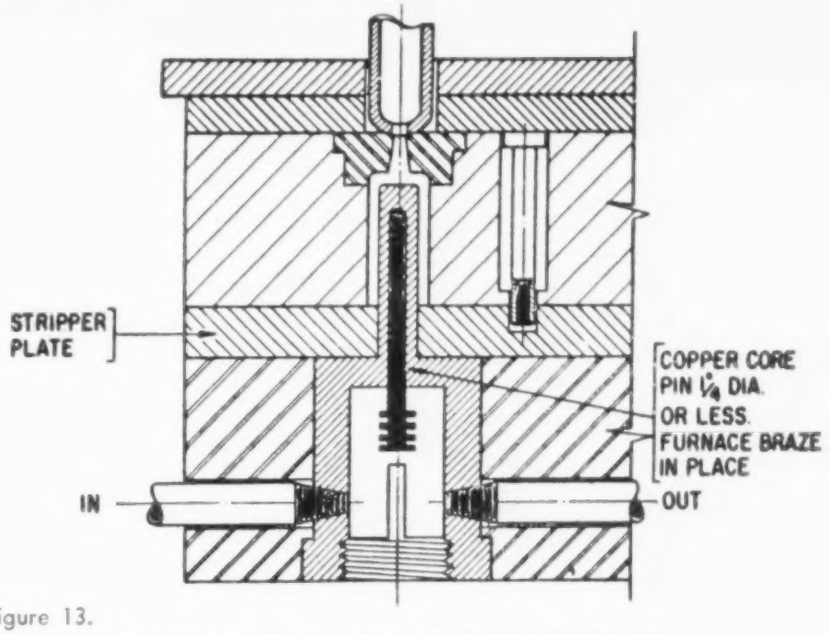
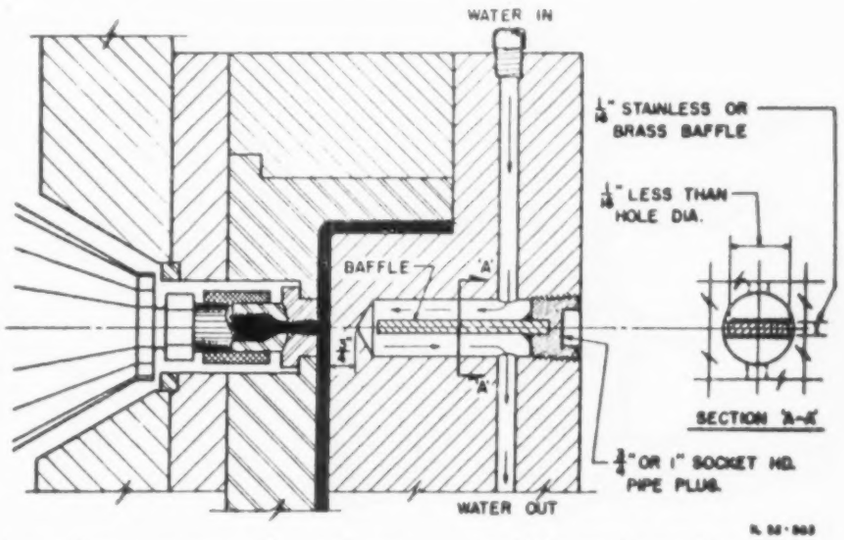


Figure 13.

BUBBLER FOR LOCALIZED TEMPERATURE CONTROL



Reinforced Plastic Reflectors

Ralph L. Mondano

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. . . a radar reflector must be rigid, dimensionally exact, hold metal attachments and be able to reflect radar. The problems encountered and their solutions are good examples of plastics engineering research . . .

THE APPLICATION of reinforced plastics in the fabrication of radar reflectors can be primarily traced to the facility with which glass-resin layups can be accurately shaped to a compound curvature. Radar reflector designers were immediately interested by the idea of being able to make an accurate male form upon which they could position some woven glass fabric, paint it with new magic liquid thermosetting resins and obtain a good mechanical structure.

In the beginning, many problems arose, such as:

1. How would the necessary metallic reflecting surface be obtained?
2. Would this structure have enough rigidity when mounted and gimballed at high accelerations?
3. What are the aging characteristics as well as creep problems?
4. How should metal attachments be made to these reflectors?
5. Is a sandwich construction more desirable than a single laminate?
6. How close could these reflectors be held to the mold?
7. What would be the actual tolerances of reproducibility to the mold with respect to each reflector?

The first problem was how to make a reasonably inexpensive mold having a compound curvature with a high degree of tolerance, such as plus or minus .003 of an inch, and able to withstand the handling and usage encountered in making a reinforced plastic part. After considering several materials, it was decided to attempt to fabricate the mold from phenolic tool resin. This mold was hand worked and completed to required tolerances by the use of several sets of accurately finished metal templates.

This paper was presented at the SPI Reinforced Plastics Division conference in Chicago.

First Approaches to Construction

The next step in trying to get a reinforced plastic piece reproduced from this mold resulted in a disaster. An attempt was made to fabricate the reflector by laying up and curing the outside skin, the honeycomb and the inside skin on the mold all in one step. The approach was to use a rubber blanket technique, put the sandwich construction assembly in an autoclave, subject it to the steam temperature and pressure and, presto, complete the part. This proved a costly venture. The large heat differential caused by the rapid introduction of heat to the outside surface of the mold caused it to shatter and fracture into many pieces. Further afterthought suggested that more reinforcement should have been used in the fabrication of the plastic mold.

A second plastic mold was fabricated and a reflector made using the vacuum bag technique. The assembly was laid up in steps and each layup was cured under heat lamps. We discovered that the dimensions of the plastic mold changed from week to week, distorting under average atmospheric conditions. Changes were not on the order of thousands but **tens** of thousandths of an inch.

The natural sequence, of course, was to design and build an all-metal mold. Most reinforced plastic manufacturers have concluded that a good reinforced plastic part requires a well-designed metal mold. This holds true regardless of the process, whether it be press molded or vacuum bag formed.

On this metal mold we were able to fabricate successfully the first sandwich reinforced plastic reflector, but, unfortunately, not suitable to the radar people. We used polyester resin and glass skins and polyester glass based honeycomb. We ran mechanical checks on the com-

pleted reflectors to compare them to the molds and found our plastic reflectors to be out as much as .030 of an inch. This again was in no way uniform and resembled a distorted effect. Several polyester glass honeycomb sandwich reflectors were fabricated and each one exhibited poor performance when subjected to radar tests. At this time we were using aluminum wire screening embedded in the face laminate of our reflector for the necessary radar reflecting surface. We certainly did not want to use epoxy resins to make radar reflectors if it could possibly be avoided. This was mainly due to the difficulties encountered in handling and releasing of the epoxy part from the mold.

Epoxy Resin—Aluminum Screen

Our feelings gave way to necessity and we fabricated the first epoxy resin reflector again using aluminum screening as the reflector face. This reflector performed better electrically than any of the previously made reflectors. This, we concluded, was due to lower shrinkage and better stability of epoxy resins. Further work with epoxy resins convinced us of the need for accurately controlled curing temperature and time schedules in order to obtain a minimum of distortion.

Up to this point in our investigation of plastic reflectors, we had purposely avoided considering internal and external ribbing and reinforcing. We felt that first we must learn what a simple reinforced plastic sandwich without any ribbing could do. We had made a honeycomb sandwich with an epoxy front skin involving a special edge reinforcement, glass polyester honeycomb and a top skin of epoxy and glass, the reflector face being aluminum screening. In some reflectors, especially the airborne ones, the requirements of weight and space dictated that, if possible, we should have no ribbing or build-up beyond reasonably thin honeycomb sandwiches. This led us to consider internal ribbing. (See Figure 1.)

Adding stiffening members between the two skins was found to be extremely satisfactory. In fact, this produced the first suitable plastic reflector. External ribbing that would increase the thickness of the plastic reflector structure could also give added rigidity and resistance to distortion.

Conductive Coatings

One of the problems that would be faced in production was the shaping and the positioning of the aluminum screening. Because of this problem, consideration was given to the use of other types of conductive coating. Several techniques such as conductive lacquers, electrodeposition, electrodeless plating and metal spray appeared feasible. One of our recent developments is a laminating resin sufficiently conductive to be suitable for a radar reflective surface.

Reinforced plastic has been again successfully applied in the manufacture of a product, and offers a suitable technique for producing the reflectors required by the electronics industry. One obstacle at present is the temperature performance limitation. Plastic reflectors have been built and tested which have suitably performed up to temperatures of 275° F. Higher temperature resins stable at 500° F. offer promise of overcoming the present temperature performance limitation.

Referring to the problems mentioned at the outset of this paper, answers in a few cases had to await the results of field tests. Concerning whether or not the structure would have enough rigidity at high accelerations when mounted and gimballed proved no problem. In fact,

Figure 1. Internal Reinforcement.

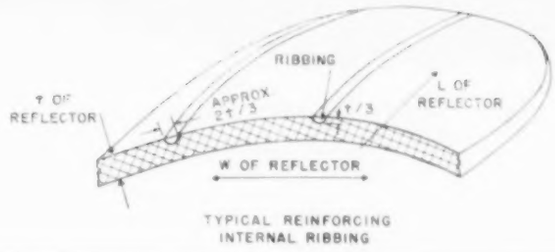

Figure 2. Method of Holding Inserts.

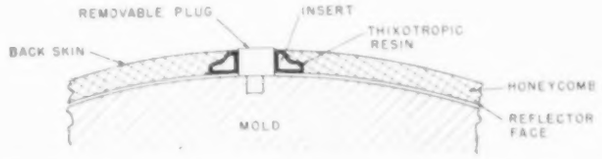

Figure 3. Sandwich Structure.

in very rigid drop test the equipment attached to the reflector was severely damaged, while the reflector showed no visible signs of damage. With regard to the aging characteristics, the chief concern of which was creep or distortion, to date all indications are that the epoxy-glass reflectors are remaining within operational tolerances, which would indicate the retention of mechanical tolerances. Some of these reflectors have been in operation for as long as three years.

With regard to metal attachments, the fact that it was possible to include inserts in the mold to decrease the time and effort of locating and positioning attachments as well as having through holes for wave guide horn feeds proved a valuable innovation to our manufacturing technique. Pins and plugs could be designed to hold inserts that would remain an integral part of the sandwich structure similar to that shown in Figure 2.

Sandwich Construction

A sandwich construction was found to be much more desirable than a single laminate mainly because it proved to have the best weight-stability factor. Reflectors were fabricated up to a laminate thickness of $\frac{3}{8}$ of an inch, mainly to study the dimensional stability possible. An attempt was made to obtain the best possible solid laminate reproduction of the mold by utilizing staggered orientation of glass fabric and a slow, low temperature cure technique. Even with this, the laminate structure proved less satisfactory than the sandwich structure.

The actual degree to which the best sandwich structure reflectors could be held to the mold varied with the reflector size, design and shape. A simple parabolic reflector displayed exceptionably good reproducibility. However, it defied techniques to establish tolerances, as the problems encountered in measuring the mold versus the finished piece proved inconsistent. ★ ★

Editor Ernest P. Moslo

Jean Otis Reinecke is a Fellow of the American Society of Industrial Designers, past president and chairman, and is presently on the Board of Directors. He has been a member of the Society of Plastics Engineers since 1943.

In 1935 he was a co-founder of Barnes and Reinecke, with a staff of 375 designers and engineers.

He formed Reinecke and Associates in 1948 to offer a chance for more personal direction of design projects. These have included the "Toastmaster", "Scotch" tape dispensers, and over 15,000 projects for such clients as Amana Refrigeration, Inc., Caterpillar Tractor Co., Chicago Molded Products Corp., Federal Tool Corporation, and Zenith Radio Corporation. Recognition of this performance has come in the form of eleven awards from Modern Plastics, Wolfe, I.D.I., Society of Motion Picture Directors and Art Directors awards.

Jean O. Reinecke

Industrial Design and the Plastics Engineer

Jean O. Reinecke

Reinecke and Associates
Chicago, Illinois

Getting a team of horses to pull together when there's a heavy load makes good sense. It also makes good sense to form strong allies within the industries and professions pulling together under a heavy load of technological advances.

The relationship of industrial design to the plastics industry is a close one. With the need to develop design applicable to the special needs of new plastics, and develop types of plastics for upcoming designs, the kinship is one whose continuance can be safely predicted.

The results are beneficial for the plastic industry in several ways.

Good design presells the end user on the value of the plastic material before that material proves itself to the ultimate consumer in actual use. A product so designed that it conveys the appearance of strength, durability, flexibility, or whatever characteristics the product actually incorporates, gives the material a built-in hallmark of quality. Design can give "product assurance" even when the product is not bought primarily for appearance. This *apropos design* is not yet a science as the chemical field defines the word; but there are definite gains in professional knowledge of what will be a saleable design. This knowledge is one part of the industrial designer's equipment for his job. It can be of infinite help in achieving "promotability" in plastics materials.

"Promotability" extends from the end use of plastics back to the source in a very simple manner: the number of over-the-counter sales is the determining factor for the recorder of molded pieces; the number of molded pieces governs the use of the raw material. The designer working directly with the manufacturer is working indirectly for the benefit of the molder, and just as surely, if more remotely, for the basic supplier.

The market value of design is most readily demonstrated in the automobile industry because of the comparatively limited number of products and producers, the large dollar volume, and the practically simultaneous appearance of new designs. Design is most certainly a primary factor in the auto leaders' share-of-the-market percentage figures. A year ago General Motors dominated the market to the extent of 52%, with Ford at 26.7 and

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MOLDING CYCLES

Edited by Louis Paggi, *Consultant, E. I. du Pont de Nemours & Co., Inc.*

Safety Factors in Plastics Molding

Louis Paggi

THE importance of safety in any operation has long been recognized by the great majority of large and small companies. As a result, a great amount of effort is constantly expended to locate and eliminate existing hazardous conditions. Unfortunately, however, many existing hazards are not recognized until they have taken their toll. This is particularly true in new operations or in operations where the importance of safety is minimized. Constant alertness to hazards and periodic safety inspections are the best safeguards against accidents.

Among the many benefits to be derived from a safe operation are:

1. Prevention of injury. This is obviously the most important benefit to the individual.

2. Less absenteeism from the job. The unexpected and unscheduled absence of a key person from a large operation may be as harmful as the absence of the one man from a one man operation.

3. Better and more production due to less tension on the job.

4. Lower insurance premiums. In general the rates on insurance are in direct proportion to the risk. Quality and production of work as well as employee relationships will improve in the presence of good safe working conditions.

From a standpoint of actual and potential hazards involved, the molding operation should be viewed with respect. Few operations will be found where a greater number and variety of hazards exist.

Machines are often operated without guards and with safety devices deliberately locked out or accidentally made inoperative. Such conditions create tension in the operator.

Following is a list of known hazards with recommendations for eliminating them.

1. Hoisting and Mounting Molds

Be sure the weight of the mold does not exceed the safe load limit of the hoisting or mounting device.

When bolts are used, be sure the threaded section is engaged to an extent at least equal to the diameter of the thread.

Figure 1 shows an "Eye" bolt equipped with a nut for a visual guard against engaging it too lightly.

Clamp both halves of mold together with removable metal straps bolted to each half of the mold. Old molds with worn bushings, greased molds and molds with "Eye" bolt holes off the load center can separate when hoisted.

Safety shoes should be worn by all personnel handling molds, heavy tools or machine parts, to avoid foot injuries.

2. Installation of Electrically Operated Equipment

The equipment should be permanently bolted to floors or building framework. If drop cords are used to supply current, they should be of sufficient length to prevent tension in the line. They should not be exposed to damp situations and should not be permitted to abrade against a moving surface.

The equipment should be electrically grounded. This means the use of a three wire system for simple phase current and a four wire system for three phase current with the extra wire making a firm and positive contact against the metal of the frame and against a good ground such as a water line. If three wires are used to carry three phase current, all three wires are "hot". If single phase current is split off from three phase both wires are "hot" regardless of which phase is tapped, hence the need for the extra wire.

All conduit and BX cable lines should be firmly grounded. Vibration may loosen ground connections, then abrasion of the insulation against the metal conduit or cable sheath, may result in a short circuit.

A "hot" wire shorting against an ungrounded conduit or BX shell provides an excellent contact surface for electrocution.

Certain types of heater bands, the ceramic insulated or radiant heat type, for example, are covered by a metal shell which is not grounded to the heating cylinder. The shell of these bands should be grounded for the same reason as for grounding conduit.

The terminal connections on heater bands should be insulated. Ceramic fittings and woven glass tape are available for this purpose.

All plug-in receptacles should be installed with faces perpendicular to the floor. This is to prevent small metal objects from accidentally lodging themselves into the contact ports and thus providing exposed contacts.

3. Safe Hand Tools

All tools such as pliers, wrenches, screw drivers, sprue knockout rods, and the like, which are likely to be used around the machine should be insulated at the area where they will be handled. Soft rubber tubing or rubber tape can be used for this pur-

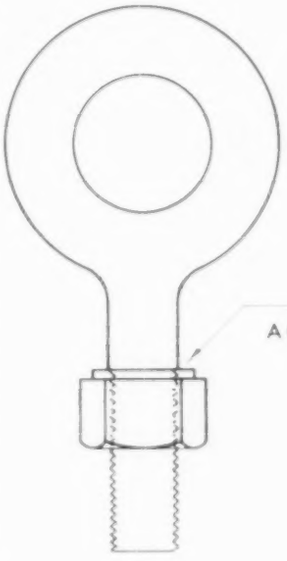

Figure 1. Visual guard insures that hoist for mold is not too lightly engaged.

SAFETY BAR DEVICE
CLOSED

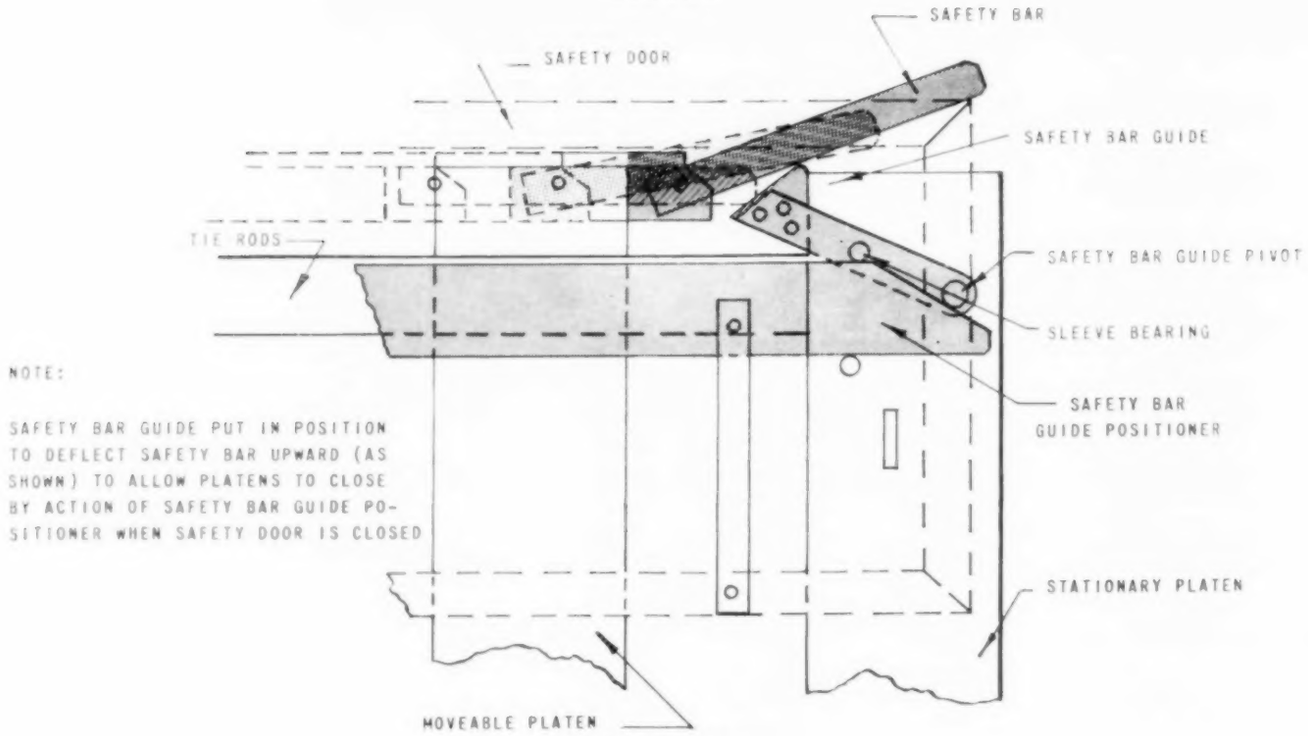
SAFETY BAR
SAFETY DOOR
SAFETY BAR GUIDE
TIE RODS
SAFETY BAR GUIDE PIVOT
SLEEVE BEARING
NOTE:
SAFETY BAR GUIDE PUT IN POSITION TO DEFLECT SAFETY BAR UPWARD (AS SHOWN) TO ALLOW PLATENS TO CLOSE BY ACTION OF SAFETY BAR GUIDE POSITIONER WHEN SAFETY DOOR IS CLOSED
SAFETY BAR GUIDE POSITIONER
STATIONARY PLATEN
MOVEABLE PLATEN

Figure 3

SAFETY BAR DEVICE
OPEN

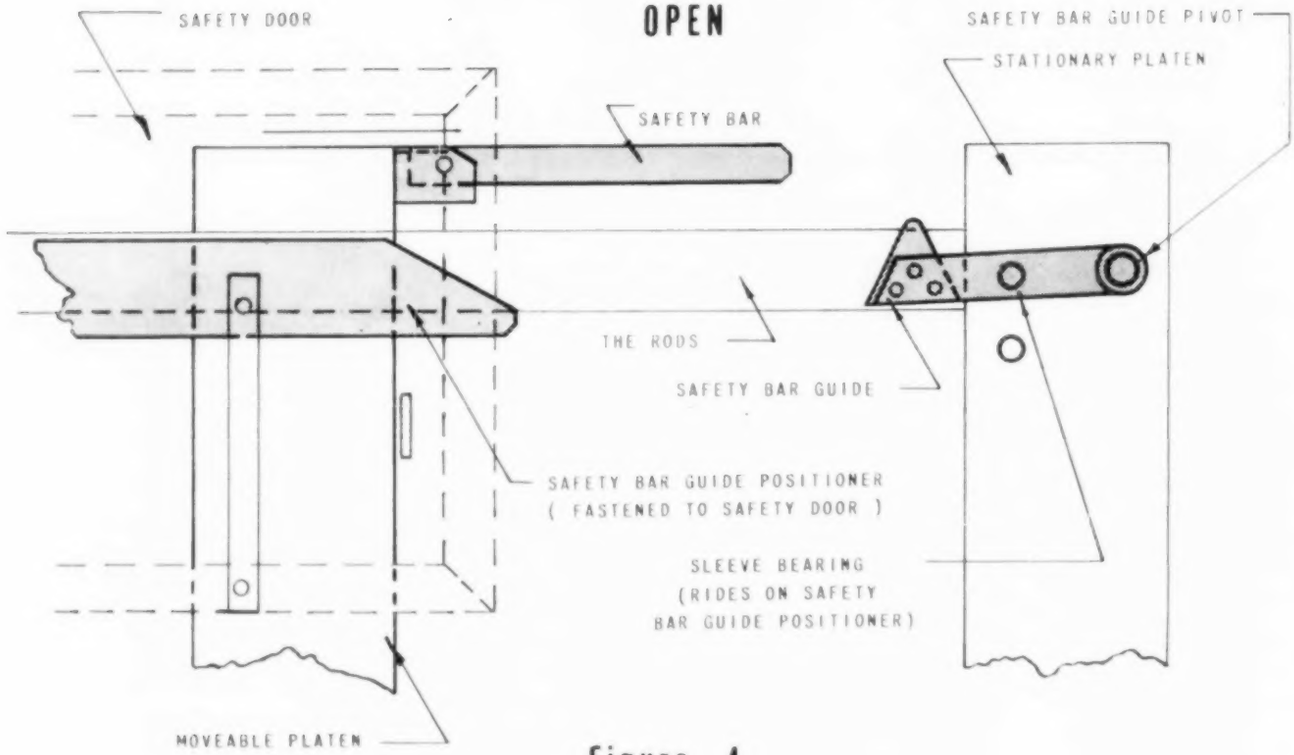

Figure 4

pose. Metallic articles such as rings, wrist watches or bracelets should not be worn when working with electrical equipment. Bear in mind that all of the above mentioned objects provide a relatively large contact area with the body. A point contact between these objects and a bare electrical source will provide a large path for a heavy discharge of current into the body thus making relatively low voltages of lethal magnitude.

As a partial precaution against contact with electricity, the operator should stand on a dry rubber mat or a dry wood platform while operating the machine.

4. Safety Switches and Locks

Most machines are equipped with safety switches and/or hydraulic locks at the front and rear of the machine. These devices should always be in use and periodically checked to determine their condition. Occasionally, molds or mold attachments may protrude beyond the position of the rear guard. In such cases, it is a common unsafe practice to remove the rear guard and lock out the safety switch. A better practice would be to fit adjustable extension bars on the bottom and top of the guard to permit mounting it further removed from the machine.

Many machines are also equipped with a combination single-cycle and automatic switch. When this switch is turned to automatic position the machine will re-cycle as long as the door is left in closed position. This switch should be in automatic position only when the machine is in full automatic operation. If the operator must reach between the open mold to remove the shot the switch should be set to single cycle position.

Listed below are a number of possible machine conditions that, in spite of the electric switch and hydraulic interlock devices, may lead to serious accidents, including fatalities.

1. Depending upon the type of machine, the method of mounting, and the way the hydraulic interlock operates it is possible for the interlock valve to remain in the "open" position. For example, it may fail to function due to loosening of mounting bolts, loosening or maladjustment of the cam rod that actuates it, or sticking of the valve plunger. In any of these eventualities the safety feature intended by installing the interlock valve in the hydraulic system no longer exists. Since the operation of the machine is in no way affected by the non-functioning of the interlock device, the defects may go unnoticed for long periods of time. To check for a defective hydraulic interlock valve, press the electric safety switch to closed position while the safety door is open. If the press closes, the interlock valve is defective.

2. The electric safety switch may become shorted or stuck in the closed position, or a short may develop between the two switch wires.

3. When the clamp timer times out and the press opens, regardless of the safety door position, a safety hazard exists in the manual removal of the shot.

4. When the between cycle delay timer times out shortly after the mold opens and the mold closes again regardless of the position of the safety door, the operator runs a risk in removing the shot.

There is another possible way for an accident to occur in spite of the electrical and hydraulic safety devices on the machine. If the hydraulic interlock should be defective and the operator leans forward to remove the shot it is possible to lean on the safety switch operated by the safety door. This would, of course, cause the mold to close, and possibly catch the operator's hand, or possibly more of his body, between the two mold halves. Such a possibility may be essentially eliminated by installing a guard around the safety switch. The guard should be open on the door side only to make it impossible to trip the safety switch accidentally.

To eliminate the possibility of the cycle starting switch and the safety switch failing at the same time due to a short between two wires common to both switches, each switch should be wired separately, and the series connection made within the solenoid valve housing. On some machines, it is possible accidentally to trip the cycle starting switch and the safety switch by leaning toward the open mold. To prevent this, the cycle starting switch should be protected by a raised guard so that it cannot be energized accidentally. Guarding the safety switch has already been covered above.

As a further safety measure, a safety stop switch which would stop all power to the machine can be installed. This switch should be readily accessible to the operator and may be operated by a raised button, a foot lever or a length of steel cable stretched across the front of the machine.

5. Safety Bars

Accidental closing of the mold can occur even though all electrical safety switches and the hydraulic interlock are operative and in good condition.

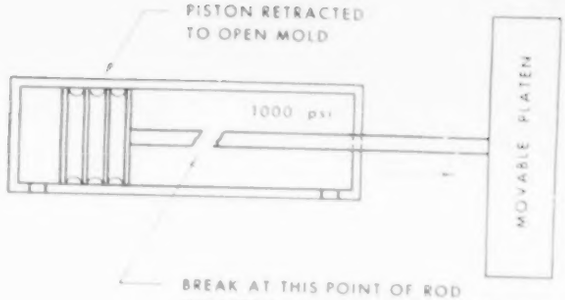

Figure 2. Broken piston rod can lead to accidental closing of mold.

In vertical clamping machines of the toggle type, this can occur by breaking of the clamp piston rod or a break in the linkage pins. In horizontal clamping machines it can occur as a result of the clamp piston rod breaking inside the hydraulic clamping cylinder and near the piston. Figure 2 shows how this occurs. To prevent accidents of this type, mechanically operated safety bars can be installed on the machine. Figures 3, 4 and 5 show the design and installation of a safety bar. While this safety device was particularly designed to suit a given machine, the same basic design can be adapted to practically any machine.

6. Other Guards

To prevent other accidents due to the opening and closing of the mold platens, guards should be installed and maintained over all moving sections of the machine. This includes guards over cam rods especially if such rods disengage from guide bushings during normal operation of the machine.

If the top of a machine can be touched easily when standing at floor level, a suitable guard should be installed over the top of the machine.

Expanded metal guards are generally satisfactory for all parts of the machine with the exception of

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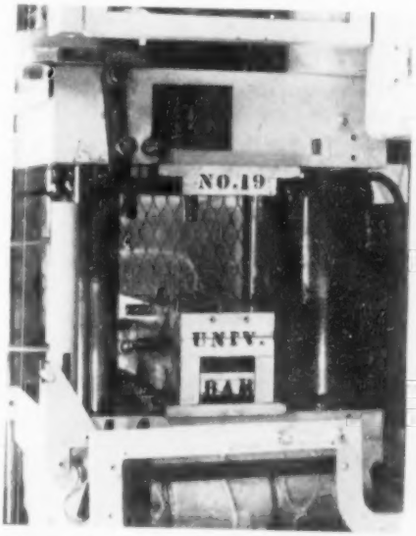

Figure 5. The safety bar installed.

SPEAKING OF EXTRUSION

Edited by R. D. Sackett
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Theoretical Extrusion Studies

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This paper reviews the progress that has been made in developing a theoretical description of the extrusion process and explores various areas in which it appears that further theoretical work could lead to useful results.

The screw extruder is one of the most versatile of all machines used in plastics processing. An extruder melts, pumps, heats or cools, mixes, and disperses, while the extruder die forms the molten plastic into the desired shape. One or more of these operations are important in almost all thermoplastic processes. For convenience in discussing the problems arising in extrusion research, each operation is considered separately in this paper.

Pumping

The most satisfying theoretical results have been obtained in analyzing the pumping action of an extruder. There are two major assumptions upon which this analysis is based. First, the plastic melt is considered to be a Newtonian fluid and second, it is implicitly assumed that any cross section of the fluid in the screw channel is at a constant temperature. The problem is essentially one of hydrodynamics in which the mathematics is simplified because our attention is limited to a single velocity component —the component directed along the helical axis of the screw, which is the only component contributing to the pumping action of the screw.

With these assumptions differential equations for the drag and pressure flow at any point in the screw channel are obtained from the Navier-Stokes equations. The final step in the analysis of the performance of a screw is to integrate these equations over the length of the screw. To do this the operating conditions must be specified. Two kinds of operation have been considered—isothermal and adiabatic.

Is isothermal or adiabatic operation ever encountered in reality? We know that both modes of operation are purely hypothetical, for isothermal operation could be attained only if the machine were at a uniform and constant temperature and the thermal conductivity of the fluid were infinitely large, while the assumptions that are implicit in the adiabatic theory could be met only by uniform heat generation in a fluid of zero thermal conductivity.

It might therefore be expected that these theories would be of little practical value, but if we perform experiments to check them the agreement is excellent. The reason for this is that the pumping action of an extruder is due primarily to drag flow (pressure flow is usually small in comparison) and drag flow is independent of the viscous and thermal properties of the fluid.

For a severe test of the theory the extruder should be operated under conditions in which pressure flow predominates. Then the non-Newtonian nature of plastic melts would be noticed and viscosity-temperature effects would become important. Under these conditions refinements in the existing flow theory would be necessary.

The Extruder Die

The screw delivers the molten plastic, under pressure, to the die where it is formed into the desired shape. Two types of problems arise. Problems of the first type are concerned with calculating the pressure requirements for a given flow rate. Problems of the second type are concerned with the relation of the shape of the extruded object to the shape of the die.

An extremely simple answer to the first problem is obtained by assuming, as was done in the case of the screw, that the fluid is Newtonian. Unfortunately, when this assumption is tested by experiment the results, in most cases, are very discouraging. We conclude that in the case of dies we must face the reality of non-Newtonian flow. This is not too difficult if the problem is restricted to **steady** non-Newtonian flow. In this case empirical relations such as the "power law" do an excellent job over a rather wide range of conditions. However, two material constants are now needed to characterize the fluid and each of these constants is a function of temperature, but, at least for long dies, this theoretical description gives reasonably useful results.

Considering die problems of the second type there is another difficulty —plastic melts have elastic properties in addition to viscous properties and elastic deformations in the die cause energy to be stored in the melt. This has a two-fold effect. If the die is short, it upsets the calculation of the pressure requirements. More importantly it causes the shape of the object emerging from the die to become distorted. Some of this distortion can be prevented by making the die long enough to allow the stresses to relax before the melt leaves the die, and sometimes improvements can be made by deliberately distorting the shape of the die to compensate for the expected dimensional changes.

Unfortunately we have only our experience to guide us in die design problems of the second type. The problem is so complicated that it appears unlikely that a completely general theoretical description can be obtained. Perhaps the most fruitful approach would be to restrict the problem to that of stress relaxation in simple visco-elastic fluids flowing through dies of the simplest possible geometry.

The Extruder as a Heat Exchanger

With the exception of the pumping action of an extruder, heat transfer appears to be most tractable to mathematical analysis. It is certainly reasonable to assume that the fluid is in laminar flow within the screw channel. Furthermore the analysis could be restricted to the case where only drag flow occurs. In addition, heat generation within the fluid could be ignored. In principle the method of satisfying the appropriate boundary conditions must be found.

While the method may be clear in principle, there is no doubt that a great deal of ingenuity will be required. Approximations will have to be found that will enable a solution

analysis is quite clear. A solution of the heat equation

$$V_x \partial T/\partial x + V_y \partial T/\partial y + V_z \partial T/\partial z = \alpha (\partial^2 T/\partial x^2 + \partial^2 T/\partial y^2 + \partial^2 T/\partial z^2)$$

to be obtained and at the same time not so oversimplify the problem as to destroy the utility of the result.

The technique of dimensional analysis offers a possible alternate approach to this problem, although results obtained by this method could not be as satisfying, as the functional relationships predicted by the analysis would contain arbitrary constants.

Melting

In almost all thermoplastic processes the plastic must be melted and extrusion is probably the most useful and economical method of melting. It is useful because it is a continuous process, because the residence time of the plastic in the machine is short, and because it compacts the material as it melts it.

In a screw melter both transferred heat and frictionally-generated heat are important. With soft materials, such as rubber, frictionally-generated heat apparently controls the process, while with hard materials, such as nylon, heat transfer is apparently the controlling mechanism.

It seems likely that a reasonably accurate description of the melting of soft materials could be obtained by modifying the adiabatic screw pump theory.

With hard materials a different approach is needed. Initially heat is transferred from particle to particle. Once a certain amount of plastic has melted however, the individual particles should be surrounded by a film of molten plastic. As the process of melting and compaction continues the extruder becomes a "slush" pump and melter. Melting rates of particles in the "slush" could be calculated by the techniques used in unsteady state heat conduction problems.

Mixing and Dispersing

It is useful to draw a distinction between mixing and dispersing. For the purposes of this discussion mixing is considered to be a material transport operation. While dispersion also depends somewhat on material transport it will be considered to be a size-reduction operation. For example, the coloring of a clear plastic by distributing a dispersed pigment concentrate throughout it is a material transport or mixing operation. The preparation of the concentrate however involves the reduction of agglomerated pigment particles and is a dispersion operation.

It is well known that screw extruders can, under some conditions, be effective mixers. At the moment however, a theoretical description of mixing in extruder screws is not available. One of the difficulties in developing a mixing theory is the lack of any accepted method of expressing the extent to which a system is mixed, and this would perhaps have to be the starting point of a theoretical study of mixing.

An alternate approach to the mixing problem might consider the analogy between the mixing of heat (heat transfer) and the mixing of material. It is possible that designs leading to a maximum uniformity of temperature in the plastic might also lead to a maximum material mixing action. If this is the case, then the heat transfer problem assumes a double importance.

Dispersion is perhaps an even less understood process than mixing. In most practical work the emphasis is placed on power and energy considerations, but this may tend to obscure what is really fundamental to the process. An approach to the dispersion problem that might prove useful would be to set up some simple mathematical models to represent agglomerated systems and then study the behavior of these systems under the application of a variety of stresses.

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Molding Cycles

(Continued from page 57)

the area around the mold and front portion of the cylinder. Here, a solid sheet metal, heavy plastic sheet or safety glass should be used. This is to prevent injury in the event hot material is violently ejected into the work area from the nozzle or parting line of the mold.

Wearing goggles while operating and a face shield while purging the machine is a further guard against injury from hot material.

7. Start-Up and Shut-Down

Many accidents have occurred as a result of improper application of the heat to a plastifying cylinder during start-up or shut-down. Most, if not all of these accidents might have been avoided if a safe procedure had been followed.

A good start-up procedure is as follows:

1. Disengage the nozzle from the sprue bushing.

2. Turn on the heat to the nozzle and front end of cylinder a few minutes before heating other zones.

3. Check to see that nozzle is heating properly.

4. Turn on center and rear heats maintaining a differential temperature of at least 20°F. higher at the nozzle and front end of the cylinder.

5. When molten material emerges from the nozzle, the desired operating temperature may be set on all zones.

If material does not emerge from the nozzle shortly after the nozzle and front end of the cylinder indicate a temperature which would normally melt the material, check to see if the instrument is correct by touching the zone in question at several points not covered by heater bands with a piece of plastic of the composition to be molded. If the plastic melts, it is safe to assume all is in good order, but if not, check for burned out or turned off bands at some point in the zone.

This procedure is recommended to avoid overheating of the center zone and causing a blow-out of material from the nozzle or rear zone due to high internal pressure.

Taking preliminary air shots after the cylinder is at operating temperature should be done at a low injection pressure and with a slow ram.

8. Shut-Down Procedure

1. Turn off rear heats and continue to mold on cycle until short shots develop.

2. Disengage nozzle from sprue bushing.

3. Turn off all remaining heats.

This recommendation is given in order to preserve a granular structure at the rear of the cylinder and thus facilitate moving material earlier during the next start-up. Failure to follow this procedure may result in the formation of a solid block of material in the rear zone. This block of material would require a considerably longer period of time to melt prior to injection, which tends to increase the hazards involved during start-up.

To avoid forgetting to turn off cylinder heats, a timer can be installed in the heater supply line. This timer should be set to turn off all heat automatically after a certain elapsed time between cycles. It will not interfere with the normal operation of the machine since it would be reset automatically with the operation of each molding cycle.

9. Preplastifying Installations

The shooting cylinder of a preplastifying installation generally is fed through a check nozzle from the plastifying cylinder. This nozzle will permit passage of material in the direction of the shooting cylinder only. There is no opening between the shooting cylinder and its plunger such as ordinarily provided by the feed section. Therefore, the nozzle remains as the only opening through which the pressure of the shooting cylinder can be relieved.

In the event that the shooting nozzle should become plugged all heats to the body of the cylinder should be turned off until the nozzle is cleared. While the bursting of cylinders is not common, it can and has happened.

10. Good Housekeeping in the Work Area

Spilled granules, oil, grease and water present slipping hazards.

Molds, tools, supply lines, etc. stored or installed well below eye level present tripping hazards. All can be avoided if we are safety minded.

★ ★

OCTOBER
1957

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

STRESS CONSIDERATIONS IMPORTANT ENGINEERING ASPECTS OF POLYSTYRENE

RIGIDITY IS NOT ALWAYS BEST INDICATION OF PLASTIC PRODUCT STRENGTH

Great care must be taken when designing a molded plastic part to avoid stress concentrations. The part must be designed so as to distribute energy absorption over as much of the area of the part as possible. Designers often place a reinforcing rib to add stiffness and the result is an area of concentrated stress which causes the part to fail after a short period under load.

Dow Plastics Technical Service Engineers have made a detailed study of the many important engineering aspects of molded polystyrene. Greater over-all strength can often be attained simply by molding a thicker part, rather than by adding ribs which may concentrate stresses.

Thermally induced stresses caused by differential cooling of the part can be reduced by proper design. As a part with an extreme difference in sectional thickness cools after fabrication, the thinner section cools more rapidly. Subsequent cooling and shrinkage of the thick section will cause a sufficient amount of bending in the already hardened thin section to introduce tensile stresses which cause crazing under small loads.

Orientation stresses caused by forced molecular alignment can be controlled to some extent by the design engineer. By considering the fabrication of the part he can usually place the requirements of maximum strength across the direction of orientation.

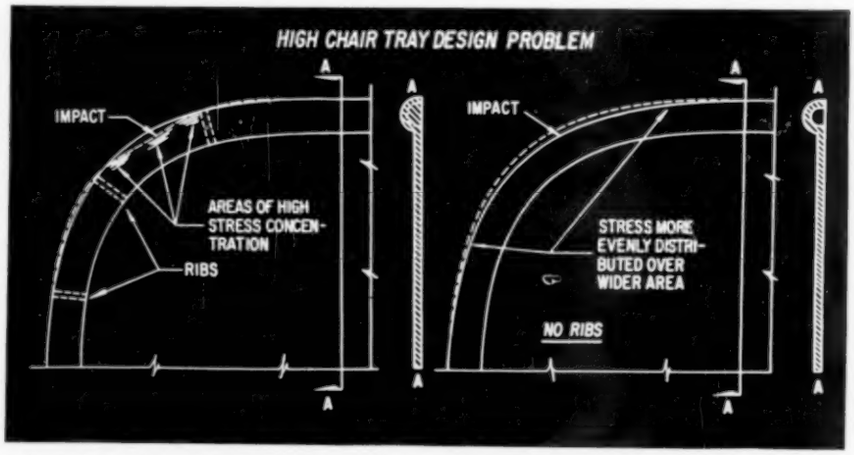
Dow Plastics Technical Service Engineers have also investigated various factors affecting the physical properties of polystyrene such as aging, temperature and environmental effects, chemical resistance, dimensional stability and many others. This is but one of a series of continuing Plastiatrics studies covering every phase of plastics formulation, design, molding and finishing. For your copy of the paper entitled, "Engineering Aspects of Polystyrene", write THE DOW CHEMICAL COMPANY, Midland, Mich. Plastics Sales Dept., 1546J.

AMERICA'S FIRST FAMILY OF POLYSTYRENES

GENERAL PURPOSE
- STYRON® 666
- STYRON 666M (Easy Flow)
- STYRON 665 (Extrusion)
- STYRON 689 (Easy Flow)

HIGH IMPACT
- STYRON 475
- STYRON 475M (Easy Flow)
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra-High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700



High chair tray shown above, left, is an example of what happened when the design was too rigid. Ribs were used extensively as shown. When the tray was dropped on its edge, the force of impact was concentrated between two ribs and the rim broke. When tray was molded without ribs, above, right, the force of impact was spread, the deflection less, and the rim did not break.

YOU CAN DEPEND ON DOW

Action— By Your National Organization

"The objects of the Society shall be to promote in all lawful ways the Arts, Sciences, and Engineering Practices and Standards connected with the utilization of plastics."

Be a Real Joiner

Noah Webster has several definitions for a joiner—one is the popular concept of: "one who associates himself with a group". Another definition pertains to the woodworking industry: "one who works at the art of securing one member to another so as to build a framework or structure". This definition has appeal and is one which every member of our society should be able to apply to himself. The key words here are **work, framework** and **structure,** and the member who does measure up to this definition is a real joiner.

The rapid and strong growth of our society in the short fifteen years of its existence has been due in good measure to the many real joiners—past and present.

All of our areas of past growth, strength, and accomplishment are too numerous to mention. Particularly noteworthy, however, are: The establishment of a strong national office; The establishment of a strong editorial staff; Technically excellent and well attended National Technical Conferences and Regional Technical Conferences; The publication of the first of our engineering volumes, with another almost complete and more to come; An SPE Journal of which we can well be proud; The activation of our first Professional Activity group and eleven others authorized; Establishment of closer relations with other engineering and sister societies.

Then there are the less obvious but none-the-less important accomplishments which require work and diligence—the publication of a manual on New Section Development; a manual on operation of Technical Conferences; rewriting the Constitution and By-Laws; and work in the area of credentials . . .all of these areas have counterparts at the local section level where there has also been excellent work done. And, all this by real joiners!

But, we have just started our upward climb. Just what lies ahead, we do not know. We do know that we shall grow in numbers and in strength. This is inevitable with such tremendous projects under way as The Plastics Institute Investigational Program, the formation of professional activity groups that will eventually cut across every segment of the industry and with the increased tempo of these activities being reflected at the local section level. We need real joiners!

Ours is a society of individuals and if you do not uphold the principles on which we are founded . . ."To promote in every lawful way the arts, sciences and engineering practices of the Plastics Industry", then the society is not living up to its principles. You have an obligation. Ask yourself—

Have you done what you can to build a strong framework and Society—Are you a **real joiner?**

Peter W. Simmons

P. W. Simmons,
National President

Technical Committees Reports

Editor: Don Biklen

Intersociety Relations Committee

American Electroplaters Society

The members of the American Electroplaters Society are becoming more interested in SPE activities due to the tremendous increase in the use of various plastic materials in the plating department.

The coating of racks was a terrific problem for many years with much costly and, at times, hard to get metals being wasted on bare racks. The plastisol coating solved this problem so it is now a standard routine to coat all racks and fixtures in the plating department with this vinyl film.

Polyester type fiberglas is used on many air ducts in exhaust systems. The vinyls are also used for this purpose.

Steel tanks are being lined with Koroseal type vinyls featuring plasticized faces on one side and unplasticized on the other giving rigid high abrasion and corrosion resistant surfaces. Many special acid resisting tanks are fabricated out of the plastic alone without the steel casement. Fiberglas was the first material used on a large scale and then polyethylene and the vinyls followed in close order. All of these materials do a specific job.

In short, the SPE must of necessity interest itself in the AES because of electroforming, plating of plastics, mask making, etc., and the AES, inversely, because of its rapidly growing increase in the use of plastics in the plating industry, as well as a need for understanding the organics, is called upon to plate or metalize in various forms.

Besides this crossing of paths engineering wise by the two societies, they have much in common in growing pains and have much to offer each other.

—Submitted by Arthur W. Logozzo

Building Research Group, Plastics Study Group

The Building Research Institute operates as a unit of the division of engineering and industrial research of the National Academy of Sciences — National Research Council. The NAS-NRC is a private non-profit organization of scientists dedicated to the furtherance of science and its use for the general welfare.

BRI membership consists of a cross industry representation of persons particularly qualified by their desire to contribute to the advancement of building research and technology. Memberships are held by corporations, partnerships, business and professional and trade associations, and individuals. Member organizations select one or more persons from their staffs to act as official representatives or technical participants in the activities of BRI.

As the technical society for the building industry, the primary purpose for the Building Research Institute is to promote the integration and advancement of building science and technology, to serve as an information center for the industry and to maintain liaison with other building research organizations throughout the world.

Following a BRI public research correlation conference, Plastics in Building, in 1954, a group of institute members formed a study group for the study of problems in the application of plastics materials in building construction. The activities of this group are arranged by a Planning Committee appointed annually by the President of the Building Research Institute. Three meetings have been conducted through co-sponsorship with the following institutions: University of Michigan — November 1955, Massachusetts Institute of Technology — July 1956, Illinois Institute of Technology — December 1956.

Meeting No. 4 was held at Washington University September 17 and 18, 1957, in St. Louis, Missouri.

—Submitted by Michael Gigliotti

American Society of Quality Control

The President of ASQC is Dale Lobsinger, United Airlines, Denver, Colorado. The Executive Secretary is L. S. Eichelberger, A. O. Smith Corporation, Milwaukee, Wisconsin. Membership as of June 1956 was 9,671. A monthly publication entitled "Industrial Quality Control" is issued. The Society is divided into six divisions including chemical and textile divisions. It holds an annual conference and five regional conferences each year in addition to monthly section meetings. It conducts educational courses at several universities. The May 1957 issue of Industrial Quality Control carried a favorable book review on the SPE publication "Quality Control for Plastics Engineers", by L. M. Debing.

The Chairman of the Chemical Division of ASQC is H. L. Wehrly, Dow Chemical Company, Midland, Michigan. This division numbers 631 members and will hold a technical conference on October 18 and 19, 1957 in Philadelphia. *—Submitted by Larry Debing*

American Group for ISO/TC61-Plastics

Several SPE members have active parts in the membership of this American Group for ISO. The Chairman is Gordon Kline, Secretary is Norman Skow, and at least four other members have committee chairmanships. In addition to carrying on work leading to technical standards, the American Group is making plans to hold a 1958 meeting of ISO in the United States. SPE will be asked to participate in sponsoring the events which are scheduled for October and early November of 1958.

Books on Plastics Engineering

A list of important books dealing with all phases of plastics, assembled by the National Education Committee of the Society of Plastics Engineers.

Having recognized the need by the plastics industry for a list of books on plastics engineering, the Society of Plastics Engineers, Inc. has assembled the following list of various technical books on and related to this relatively new engineering specialty. As part of activities of the SPE National Education Committee, John J. Chapman of John Hopkins University has generously contributed his time to organizing this compilation of both American and British books on plastics. It is hoped that this list will be useful to both industrial and educational organizations which desire to plan a well rounded library for research and educational purposes.

No claim is made that this list includes all books on plastics engineering or allied technology. Many published books on this subject have not been included because they are out of print, unavailable, or are being revised. This list can be considered a starting point or guide for any organization desiring to assemble a collection of books on plastics engineering, and it is hoped that it will be useful in this respect. SPE is fully aware that such a list can never be up to date, since new books on plastics engineering are being published each year.

To promote advancement of plastics engineering, the Society has a long-range program of encouraging publication of texts on various aspects of this engineering specialty. A series of volumes known as "The Plastics Engineering Series" has been planned as a service to industry and universities interested in plastics engineering. The first, "Quality Control for Plastics Engineers", was published this year; and it is expected that the second, "Processing of Thermoplastic Materials", will be published next year. Activities of this kind make it impossible for this list of books to ever be complete and are healthy symptoms of technical growth and maturity of plastics engineering. (compiled July 1957)

American Books on Plastics

Interscience Publishers

Chemistry of High Polymers, The; Bawn, C. E. H.

Chemistry of Large Molecules, Burk, R. and Grumitt, G.

High Polymers, Series of Monographs on the Chemistry, Physics, and Technology of High Polymeric Substances.

- Volume I—**Collected Papers of Wallace Hume Carrothers on High Polymeric Substances,** edited by Mark, H., and Whitby, G. Stafford, 1940
- Volume II—**Physical Chemistry of High Polymeric Systems,** Mark H., and Tobolosky, A. V., 1950
- Volume III—**Mechanism of Polymer Reactions,** Burnett, G. M., 1954
- Volume IV—**Natural and Synthetic High Polymers,** Meyer, K. H., 1950
- Volume V—**Cellulose and Cellulose Derivatives,** edited by Ott, Emil, Spurlin, H. M. and Grafflin, Mildred W., 1943
- Volume VI—**Mechanical Behavior of High Polymers,** Alfrey, Turner Jr., 1948
- Volume VII—**Phenoplasts,** Carswell, T. S., 1947
- Volume VIII—**Copolymerization,** Alfrey, Turner Jr., 1952
- Volume IX—**Emulsion Polymerization,** Bovey, Frank A., Kolthoff, M., Medalia, Avrom I., Meehan, Edward J., 1955
- Volume X—**Polymer Processes,** Schildknecht, C. E., 1956
- Volume XI—**Polyethylene,** Raff, R. A. V., and Allison, J. B., 1956
- Volume XII—**Chemical Analysis of Plastics,** Kline, Gordon M., (Future Volume)

McGraw-Hill Book Company, Inc.

Dielectric Structure and Behavior, Smyth, C. P., 1955

Fundamentals of Plastics, Richardson, H. M. and Wilson, J. W., 1947

Plastics Theory and Practice, Winding, C. C., and Husche, R. L., 1947

Principles of High Polymer Theory and Practice, Schmidt, A. X., and Marlies, C. A., 1948

Reinhold Publishing Corporation

Fiberglass Reinforced Plastics, Sonneborn, R. H., Dietz, A. G. H., and Heysdr, A. S., 1954
Monomeric Acrylic Esters, Riddle, E. H., 1954
Plastics for Corrosion Resistant Application, Seymour, R. B., and Steiner, R. H., 1955
Plastics Tooling, Riley, M. W., 1956
Polyesters and Their Application, Bjorksten, J., Tovey, H., Hander, B., and Henning, J., 1956
Quality Control for Plastics Engineers, Debing, L. W., 1957
Styrene, Boundy, R. H., and Boyer, R. F., 1952
Technology of Adhesives, Delmonte, J., 1947
Silicones and Other Organic Silicone Compounds, Post, H. W., 1949

D. Van Nostrand Company, Inc.

Elastomers and Plastomers: Their Chemistry, Physics and Technology
Volume I—**General Theory,** Houwink, R., 1950
Volume II—**Manufacture, Properties, Application,** Houwink, R., 1949
Volume III—**Testing and Analysis, Tabulation of Properties,** Houwink, R., 1949
Fibres from Synthetic Polymers, edited by Hill, R., 1953
Fundamentals of Synthetic Polymer Technology, Houwink, R., 1949
Methods of Cellulose Chemistry, The: Doree, C., 1946
Phenoplasts, Carswell, T. S., 1947
Physics and Chemistry of Cellulose Fibres, Hermans, P. H., 1949
Technology of Plastics and Resins, Mason, J. P., and Manning, J. F., 1945

John Wiley & Sons, Inc.

Chemistry of Cellulose, Emil Heuser, 1944
Chemistry of the Silicones, An Introduction to The: Rochow, E. G., 2nd edition, 1951
Chemistry of Phenolic Resins, The: Martin, 1956
Dielectric Materials and Applications, Von Hippel, 1954
Experimental Plastics and Synthetic Resins, D'Alelio, 1946
Fundamental Principles of Polymerization, D'Alelio, 1952
Ion Exchange Resins, Kumin and Myers, perhaps 1957
Technology of Solvents and Plasticizers, Doolittle, 1954
Vinyl and Related Polymers, Shildknecht, 1952

Additional Books

ASTM Standards on Plastics, American Society for Testing Materials
Cellulose and Cellulose Derivatives, Ott, E., Spurlin, H. M., and Grafflin, M. W., Parts I, II, III revised, 1954-55
Chemistry of Synthetic Resins, The: Ellis, C.
Modern Plastics Encyclopedia and Engineers Handbook, Plastics Catalogue Corp.
Plastic Moulding Engineering, Dubois and Pribble
Plastics in Engineering, Delmonte, J., 1942
Principles of Polymer Chemistry, Flory, P. J.
SPE Technical Papers, 11th Annual Technical Conference, Vol. 1, 1955
SPE Technical Papers, 12th Annual Technical Conference, Vol. 2, 1956
SPE Technical Papers, 13th Annual Technical Conference, Vol. 3, 1957
Technical Data on Plastics, Manufacturing Chemists Association, Inc.
Textbook of Polymer Chemistry, Billmeyer, F. W., 1956

British Books on Plastics

Ernest Benn, Ltd.

Raw Materials for Electric Cables, King A. and Wentworth, V. H., 1954

Burke Publishing, Ltd.

Plastics, Scientific and Technological, 3rd Ed., Fleck, H. R., 1951

Chapman, Chapman and Hall, Ltd.

Applied Plastic Product Design, 5th Ed., Davis, R. L., and Beck, R. D., 1947
Low Pressure Laminating of Plastics, Hicks, J. S., 1947
Modern Plastics, 2nd Ed., Barron, H., 1949

Cleaver-Hume Press, Ltd.

Elastomers and Plastomers: Their Chemistry, Physics and Technology, Houwink, R., Editor
Vol. I—**General Theory,** 1950
Vol. II—**Manufacture, Properties and Applications,** 1949
Vol. III—**Testing and Analysis; Tabulation of Properties,** 1948
Fabric Reinforced Plastics, Brown, W. J., 1947
Metallization of Plastics, The: Hepburn, J.R.I., 1947
Organic Coatings in Theory and Practice, Blom, A.V., 1949
Physics and Chemistry of Cellulose Ribers; With Particular Reference to Rayon, Hermans, P.H., 1949
Solvents Manual, Marsden, C., 1954

Huebner, Ltd.

Plastic Molds, Thayer, G.B., 1946

Iliffe and Sons, Ltd.

A Guide to Plastics, 2nd Ed. in preparation, Redfarn, C. A.

National Trade Press

Plastics Applied, Yarsley, V. E., 1946

Pitman, Pitman Publishers Corp.

Industrial Plastics, Simonds, H. R., 1947
Plastics and Building, Mactaggart, E. F. and Chambers, H. H., Pitman, Pitman Publishing Corp. 1951
Plastics Moulding Engineering, Freund, M., Pitman, Pitman Publishers Corp., 1950

Temple Press, Ltd.

Theory of Polymerization, The: Fleck, H. R., 1947
Moulds for Plastics, Holliday, W. M., 1949

Additional Books

Adhesives for Wood, Knight, R. A. G., 1952
Chemistry of Plastics and High Polymers, Ritchie, P. D., (New edition in preparation)
Synthetic Resin Chemistry for Students, Martin, S. R. W., 1950

Regional Technical Conferences

Polyethylene—Properties and Uses

SPE — RETEC — Cleveland, October 17

"Polyethylenes—Properties and Uses" is the theme of the Society of Plastics Engineers Regional Technical Conference which will be held October 17 at the Hotel Carter in Cleveland, Ohio.

The program for the conference follows:

9:30 A.M. Polyethylene-Properties

Moderator: W. O. Bracken, Hi-fax Sales, Hercules Powder Co

Introduction and History of Polyolefins—J. K. Honish—Product Mgr., New Products, Bakelite Co.

Low Density Polyethylene—R. M. Campbell—E. I. du Pont de Nemours & Co.

Medium Density Polyethylene—F. C. Sutro, Jr.—Manager, Technical Service, Spencer Chemical Co.

Linear Polyethylene—G. H. Sollenberger—Technical Coordinator, Koppers Co.

12:30 P.M. Lunch

Luncheon Speaker: Bill Veeck, Baseball Promotor

2:30 P.M. Polyethylene-Uses

Moderator: F. A. Martin, Senior Section Head, Hoover Co.

"Blow Molding"—E. E. Mills, Consultant

"Injection Molding"—Milan Krajcik, Wooster Rubber Co.

"Pipe Extrusion"—Herbert Fackler, Vice-President, American Vulcathene Corp.

"Film"—C. J. B. Thor, Visking Corp.

Advanced reservations may be sent to Mr. E. J. Haskins at Zenith Plastics Company, 3901 Superior, Cleveland 14, Ohio. Make checks payable to Cleveland-Akron Section, S.P.E.

Registration fee: (Includes luncheon and preprints)

Advance	$ 9.00
At Conference	$10.00

Plastics for Airborne Electronics

Southern California—Los Angeles, November 11.

The Southern California Section of the Society of Plastics Engineers has completed the details of their forthcoming Regional Technical Conference. The committee for the program announced that an unusually large attendance was expected, since "Plastics for Airborne Electronics" is a topic of national importance.

A highlight of the discussions will be a first hand account of the earth's satellite by Mr. J. J. Markarian, the project engineer. Eleven additional subjects will be covered during the day. Topics include new data on the electrical, chemical, and mechanical properties of various plastics.

The RETEC is being held on Monday, November 11th, at the Ambassador Hotel, 3400 Wilshire Boulevard, Los Angeles, California. Advance registration is $8.00, which will include luncheon and a booklet containing the technical papers.

KEYNOTE LUNCHEON ADDRESS

"Plastics in the Earth's Satellite — Project Vanguard", J. J. Markarian, Glenn L. Martin Co.

Advance Registration — $8.00

Includes Luncheon and Booklet Containing Technical Papers

Send Inquiries and Registration Fee To:

Society of Plastics Engineers
(Southern California Section)
c/o Jack G. Fuller
Hercules Powder Company
3460 Wilshire Blvd.
Los Angeles, 5, California

Abstracts of Papers

Effects of Hardeners on The Electrical Properties of Reinforced Epoxy Laminates

J. E. Carey & R. M. Maybee, Shell Chemical Corp.

Electrical properties of epoxy resin-glass-cloth laminates and the electrical properties of castings and glass cloth laminates prepared from several epoxy resin systems are presented. The discussion will also include:

1. A review of available data showing the effects of temperature up to 200°C and frequency up to 10,000 megacycles.

2. Dielectric Constant and dissipation factors.

3. Curves showing the effect of temperature up to 200°C. on conductivity.

Prediction of Mechanical Properties Through Determination of Electrical Properties of Plastics

J. Delmonte, Furane Plastics Inc., Los Angeles, Calif.

There is ample evidence of correlations between the electrical properties and mechanical properties of plastics. A typical high temperature epoxy potting resin and laminating resin is evaluated, and correlations established under the following conditions:

1. Cure time at different temperatures.

2. Properties at different temperatures after full cure is attained.

3. Properties after different environmental and temperature exposures.

Abstracts of California RETEC papers . . .

In general lower loss factors at various frequencies are observed for the higher tensile and flexural strength materials.

A typical epoxy resin formulation is selected and appropriate flexibilizing agent introduced. Variations in mechanical properties are ascertained and correlated with the electrical properties. Volume resistivity at various temperatures, as well as loss factors at different frequencies are plotted. Electrical losses are much greater for the more highly flexibilized resins.

Electrical Properties of Plastics as Influenced by Cure Conditions
J. J. Knudsen, Delsen Corp.

A review of some of the electrical properties of insulating materials commonly utilized in practice with comments as to their meaning and method of measurement. Typical values for dielectric constant, dissipation factor, loss factor, volume and surface resistivity, are resistance, and dielectric strength are given along with remarks as to desirable values for particular usages.

A description of the behavior of the electrical properties of a particular potting compound from the time of mixing of resin and hardener to the effective end of the cure is presented. Also examined are the effects of temperature and humidity on the rate of cure and on the final electrical properties.

Inorganic Plastics and Synthetic Mica for Electronic Systems
J. H. DuBois, Vice President Engineering, Mycalex Corporation of America

To serve this higher temperature market for molded products and sheet fabricating materials, new inorganic plastics have been developed which make use of synthetic mica. These products have substantially increased thermal endurance, better electrical properties, lower density and improved machinability over old formulations. Additional advantages are in improved arc, radiation and moisture resistance as well as total dimensional control and dimensional stability with new hermetic sealing properties.

Typical airborne electronics applications will be shown and basic design factors presented covering printed circuits for critical applications, high temperature radomes, connectors, relays, circuit breakers and gyros. In addition synthetic mica fillers for the organic plastics will be discussed.

New Developments in Isocyanate Based Polymers
Dr. M. E. Bailey, National Aniline Div., Allied Chemical & Dye Corporation

Polymers prepared by the reaction of isocyanates with compounds containing active hydrogen atoms have progressed a long way, both in a technical as well as in an economic sense, from where they were following the activity of the Germans in the field during World War II. Several isocyanates, particularly tolylene diisocyanate 80/20 and diphenylmethane diisocyanate, are now in good commercial supply in this country. The range of materials with which these isocyanates can be combined to produce useful products has been widened considerably. Thus, it is becoming possible to take advantage of the excellent chemical and abrasion resistance and good electrical properties of these polymers in more and more end use applications.

Recent Months Have Seen:

The development of a new type of flexible foam for comfort cushioning, substantial progress in our understanding of the fundamental requirements of shock absorbing padding, and how to formulate these materials, the invention of new materials and formulations for making rigid foams, which brings these foams into the realm of practical use in the building, transportation and refrigeration industries, and improved surface coatings, adhesives and potting resins.

These recent developments will be reviewed from the standpoint of chemical formulation of the products as well as their physical and electrical properties.

Silicones in Electronic Systems
K. H. Hoffman, Dow Corning Corp.

The stability of silicones employed for electrical insulation has been recognized for some time as an important factor where wide variation in humidity, temperature and frequency is encountered. This stability coupled with the actual electrical properties give reliability worth consideration where airborne electronic systems are being considered. This paper gives data on the various electrical properties of several classes of silicones as a function of temperature, time, humidity and frequency. Silicone resins for impregnating, molding and casting are discussed. Applications utilizing these properties are shown.

Encapsulations for Airborne Electronic Systems
Lloyd A. Dixon, Jr., Houghton Laboratories, Inc.

What would make an ideal encapsulating or potting material for airborne electronic systems?

Experience in the last ten years has shown that an ideal system must protect the system components over a wide temperature range; for example, the components must be protected from moisture, vibration, and shock. An ideal material must be capable of withstanding temperatures of −80°C to 200°C and under mechanical stress. The electrical properties are also extremely important. Epoxy resins possess most of these properties.

Examples of electronic equipment which have been cast are: transformers, coils, capacitors, transistors, wire wound resistors, rotating equipment, modular assemblies, slip ring assemblies, and rectifiers.

New resin developments, where flexibility is incorporated into the normally hard unmodified epoxy resins, promise to give the design engineer a new tool with which to work. Flexibility has been achieved by the addition of reactive plasticizers, such as trimer acid, to basic epoxy resins. Transformers encapsulated in trimer acid-modified epoxy show outstanding resistance to thermo shock.

California RETEC Committee

Standing: Jack G. Fuller, Donald A. Hamilton, John A. Stahmann. Seated: Leonard J. Costanza and Walter Kadlec.

Copolymers of epoxy resins and silicone resins produce flexible polymers with outstanding heat resistance, electrical and physical properties. The epoxy silicone copolymers have been developed especially for the encapsulation of electronic systems where difficult operational conditions are encountered.

The modified epoxy resins, where flexibility can be obtained without the sacrifice of heat resistance and mechanical strength, are a definite advancement towards the design engineers' goal for an ideal encapsulating material.

Polyurethanes in Electronic Systems
Dr. S. J. Assony and S. Chess, American Latex Products Corp., Hawthorne, California

Polyurethanes, consisting of polyfunctional reactants cured with polyisocyanates, are a relatively new and valuable class of materials available to the electrical and electronics industries. Certain combinations of diols, castor oil, diamines, polyesters and polyglycols with polyisocyanates produce, in addition to the superior wire coatings, potting or encapsulating compounds with excellent physical and electrical properties. These properties include an unusual range of flexibility or hardness at high and low temperatures, toughness, abrasion resistance, tensile strength, excellent dielectric, resistance, power factor and breakdown properties, superior chemical, oil and moisture resistance, power factor and breakdown properties, low permeability to gases and outstanding resistance to oxidative degradation. Thus, these potting and encapsulating compounds make highly valuable electrical insulators for use under humid conditions and at high temperatures and where vibration dampening and ability to withstand hard wear are factors. In these respects, polyurethanes are superior to the usual ozokerite, beeswax, bitumen oil, etc. potting compounds. By the use of suitable fillers, plasticizers and other additives and by variations in the basic formulations, polyurethanes can be tailored to an indefinite variety of physical, chemical and electrical properties to meet the varied needs of the electrical and electronic industries.

Plastic Coatings—Conductive and Insulating
Elbert Davis, Plas-Kem Corp.

1. Types of materials used as film formers and as binders for conductive fillers.

A. Organic Resins. B. Inorganic low temperature fusing materials. C. Organic—Inorganic mixtures.

2. Types of fillers:

A. Conductive: (1) Carbon blacks. (2) Graphites. (3) Ferrous metals. (4) Non-ferrous metals. B. Insulating: (1) Inorganic compounds.

3. Methods of application and fabrication.

4. Physical, Thermal and Electrical Characteristics.

5. Illustrative examples and display samples showing typical applications of conductive and insulating coatings by West Coast Applicators.

Quality Control of Printed Circuits for Airborne Electronic Systems
B. A. Gerpheide, Hughes Aircraft Co., Inc.

Manufacture of electronic equipment employing etched circuitry depends to a great extent on the quality of the plastic laminate to provide the equipment reliability necessary in modern airborne electronic systems. The laminate base material serves many purposes as it is currently employed in etched circuit assemblies. Mechanically the board must provide physical support for components and conductors, employ economical space utilization, be light in weight, and capable of drilling, blanking and punching, be mechanically stable and withstand handling in factory and field.

Chemically the laminate material is exposed to the elements of time, temperature, humidity, sand and dust, high altitude, industrial gases and fuel oil. Laminate material must provide a long life bond for the conductor material which essentially remains unchanged on the shelf or in the field. Laminate material must be designed to withstand the chemicals used in processing, such as ferric chloride, hydrochloric acid, cleaning alkalies, hot water, organic solvents and fluxes.

Dielectric and Mechanical Properties of Antenna Window Materials for Elevated Temperature Use
N. M. Mitchell and M. A. Nadler,
North American Aviation Co.

The success of the Navaho flight control system depended upon undisturbed transmission of radar and radio signals through various radomes. Factors affecting this transmission included variations in dielectric properties of the radome materials as influenced by temperature changes. It was, therefore, necessary to evaluate dielectric and mechanical properties of the proposed radome materials under anticipated environmental conditions. Two reinforced plastic materials which were so evaluated were American Reinforced Sales CTL 91-LD phenolic resin impregnated 181 Volan A glass fabric and U. S. Polymeric DC-2106 silicone resin impregnated 181 Volan A impregnated glass fabric. The combinations were made of dielectric constand, dissipation factors, dielectric and compressive strength, and dielectric and compressive modulations as features of temperatures (up to 800°F.), time of exposure (up to 9 hours), and weathering.

The papers presented at the last three SPE Annual National Technical Conferences are available as SPE Reprint Volumes I, II and III.
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NEWS of the industry

Heat Forming Tool

The Polymer Corporation of Pennsylvania announces the availability of a new tool known as a "Permabender" to be used for heat forming permanent bends in Nylaflow pressure tubing, the company's new polyamide tubing. The unit is expected to be of assistance where preformed symmetrical lines are required in instrumentation and other fields.

Further information is available from The Polymer Corporation of Pennsylvania, Reading, Pennsylvania.

Lynch Buys Robbins

The Lynch Corp. of Anderson, Indiana has purchased the Robbins Plastic Machinery Corp., Elkhart, Indiana. Lynch plans to operate Robbins Plastic as a wholly-owned subsidiary retaining its present personnel. The purchase of Robbins Plastic provides Lynch Corp. with facilities to make dies, fixtures and machinery used for manufacturing and handling extruded plastics and blown plastic film.

Glyptal Office Change

Consolidation of sales headquarters for Glyptal alkyd resins and polyester resins, with manufacturing facilities at Anaheim has been announced.

West Coast headquarters for the Company's chemical materials department have been moved from the former Los Angeles address (1052 West Sixth Street) to: Chemical Materials Department, General Electric Company, 1211 North Olive St., P.O. Box 630, Anaheim, California, Phone: KEystone 5-2171.

The organization has established a San Francisco sales office at 436 Peninsular Avenue—San Mateo, California—Phone: Diamond 2-2054. The Company will be represented at that location by R. M. Kavish.

Nylon-Teflon Plant

The United States Gasket Co. Plastics Division of the Garlock Packing Company has placed in operation a new Nylon-Teflon Extrusion Plant, said to offer the most complete modern facilities and advanced technique for plastics extrusion available to industry today.

Products being produced in this new Camden, N. J., addition include completely bubble-free Nylon rod in diameters up to 3 inches; Nylon sheet and tape, 12 inches wide, in thicknesses from .002 inch to ⅛ inch; and Nylon pressure tubing in diameters from ⅛ inch O.D. to ½ inch O.D. in two types—for 1000 psi and 2500 psi.

American Molding

American Molding Company, one of the West's largest custom plastic molders, announces the establishment of Southern California engineering and sales offices at 6057 Wilson Avenue, Hollydale, California (telephone— Nevada 6-6094).

Albert J. Sills has been appointed district manager of the office. Mr. Sills has many years of plastics experience in the Los Angeles area.

The opening of the new office is part of a general expansion program. American Molding Company recently moved into their new, modern plant of 45,000 square feet at 2002 Davis Street, San Leandro, California.

Hopper Loader

A new hopper loader of extra large capacity has recently been placed on the market by C. H. Whitlock Associates, 21655 Coolidge Highway, Oak Park 37, Michigan.

The new model, designated as the 1000 Series, has a capacity of **1000 lbs. per hour** with average material—twice the capacity of the company's 500 Series which has been in widespread use over a period of years.

It handles all free-flowing materials, either virgin or reground, including dry color materials (with Filter Cone Attachment). Among its other advantages is its extra height which permits the use of all palleted containers.

Petrothene

National Petro-Chemicals Corporation will be in commercial production of medium-density polyethylene before the end of this year, it was announced by Dr. Robert E. Hulse, Vice President in charge of chemical activities for the parent company, National Distillers Products Corporation. A high pressure production technique will be used in Petro's existing polyethylene plant at Tuscola, Illinois to produce these medium-density polyethylenes. The newer materials will be sold under the established trade mark, Petrothene, through the sales organization of U.S. Industrial Chemicals Co., Division of National Distillers.

Mylar Price Reduced

The Du Pont Company has reduced the price of most types of "Mylar" polyester film by 25 cents per pound. The reduction applies to all coated and heat shrinkable types of "Mylar," and to types A and D in all gauges.

Vacuum Forming

A new, large size vacuum forming machine called the **"Master-Vac"**, has been introduced by The Auto-Vac Company of Bridgeport, Connecticut. This machine features a 21-square foot (42" x 72") forming area, with roll feed and semi-automatic take-off for single-operator, high speed, continuous production of thin gauge (5 to 15 mil range) plastic articles. Rolls up to 44" wide are handled with ease at feed rates of 540 feet per hour. It may also be used with heavy gauge sheet plastic up to .125" thick.

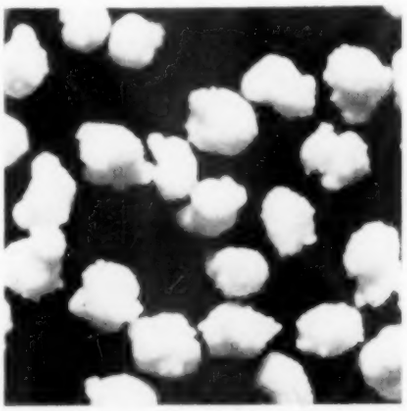
Zytel Price Reduced

Du Pont reduced the price of its "Zytel" nylon resins September 16. An over-all decrease in price of approximately 10 per cent applies to all formulations of nylon molding powders. Individual prices depend on quantity ordered and type of resin. "Zytel" 101, the general purpose molding powder, for instance, will be reduced 15 cents, to $1.18 per pound in truckload quantities.

Semet-Solvay Expands

The Semet-Solvay Petrochemical Division of Allied Chemical & Dye Corporation have announced a significant expansion of production facilities for Emulsifiable A-C Polyethylene 629. Since its introduction approximately 2 years ago this water emulsifiable form of A-C Polyethylene has gained rapid acceptance for polish, textile, paper, building materials, and a wide variety of other uses.

Polyvinyl Chloride



Unusually low fines in a general purpose straight polyvinyl chloride resin are shown in this photomicrograph of Escambia PVC resin, taken in the research laboratories of Escambia Chemical Corporation. Included in this new series of PVC resins being manufactured by Escambia are Escambia 1200, Escambia 1225, and Escambia 1250. The resin is magnified 40 times to show its uniform particle size and low fines. These qualities are important in reducing dust problems and in improving the free-flowing characteristics of hot premixes and dry blends.

"Quality Control" Gets Good Reviews

Reviewed by D. S. Davis
Professor of Engineering
University of Alabama

Reprinted from "Chemical Processing", July 1957, by permission)

Every once in a while some publisher, thoughtfully but with a measure of courage, comes up with a book designed to give authoritative answers to questions in a growing field of technology and planned to entice the reader into delving deeper into the subject than he had ever intended. That's what Reinhold, aided and abetted in general by the Society of Plastics Engineers, has accomplished in this volume, "Quality Control for Plastics Engineers."

Lawrence M. Debing and ten capable assistants who know how to write, discuss, with clarity, normal frequency distributions, control charts for variables and attributes, specifications for use under statistical quality control, inspection by sampling, statistical correlation, analysis of capability of a process, significance of data, and statistical experiments. Although applications are to the production of plastic parts, no knowledge of the technology of plastics is necessary for a grasp of the subject. Treatment is broad, informative, and with a delightful beckoning quality that a serious reader can scarcely resist. Style is clear, direct, and definitely lively.

The excellent chapter on significance, by Gilbert L. Peakes, contains well-chosen illustrative matter, and is itself highly significant of the aims and achievements of the project. In 142 pages, fortified with 48 figures and supplemented with tables for the distribution of F, for chi-square, and for the "t" test, the editor and coauthors have made a real contribution to the literature of quality control.

Society of Rheology 1957 Annual Meeting

The Society of Rheology will hold its 1957 Annual Meeting in Princeton, New Jersey, on November 7, 8, and 9, 1957. The technical sessions will be held at the Textile Research Institute. An important feature of the meeting will be the award of the Society's Bingham Medal. This will occur on Thursday evening, November 7th, in connection with the Social Hour Smoker planned for the meeting.

The Committee for the Bingham Medal, with Professor John D. Ferry as Chairman, has selected Dr. Clarence M. Zener to be this year's medalist, in recognition of his important work on the viscoelastic behavior of metals. The presentation of the medal will include a discussion of the research activities of the medalist by Dr. Arthur S. Nowick, of the IBM Watson Laboratory, Columbia University.

Men In The News

Dr. James M. Church

Dr. James M. Church, professor of chemical engineering at Columbia University, has been elected a Director of Riverside Plastics Corporation, it was announced today by Harry C. Tomford, Riverside President, following a meeting of the company's Board of Directors.

A member of the faculty since 1940, Dr. Church is in charge of the Organic Chemical Technology of the Department of Chemical Engineering, which includes courses of instruction and research in the fields of organic chemical processing and plastics, a field in which he has become an outstanding authority.

Prior to his return to academic work, Dr. Church spent eight years with the Organic Chemicals Division of Monsanto Chemical Company in St. Louis, Missouri, as a research chemist and development engineer. During his sabbatical leave in 1953-1954, he spent the entire year with the Polychemicals department of the duPont Company in high polymer research and development.

Dr. Church is very active in many scientific and professional societies which have included the Chairmanship of the Education Committee of the Society of Plastics Engineers (1950-53), Chairmanship of several Polymer Symposia of the Industrial and Engineering Chemistry, Division of the American Chemical Society (1955-57), a member of the General Committee of the Rubber and Plastics Division of the American Society of Mechanical Engineers and other similar assignments.

Dr. Church has been a technical consultant to several chemical and plastics companies in the New York metropolitan area, and is well known for his authorship of many technical papers from his various researches in the fields of plastics and organic chemical processes.

Stanley Bindman

Stanley Bindman, vice-president of Jamison Plastics Corp. of North Bellmore, L.I., N.Y., recently was the recipient of an award from the Society of Plastic Engineers. The citation presented by the New York chapter, reads, "To Mr. Stanley Bindman, for his many years of diligent and devoted service to the New York Section of the National Society of Plastic Engineers Inc." It is signed by Irwin I. Rubin, president and Herbert J. Weky, secretary. Mr. Bindman has been a member of the SPE since 1946, and has served as National vice-president, and president, of the New York Section.

Frank W. Egan

The appointment of Frank W. Egan of Brielle (N.J.) as chairman of the board of Frank W. Egan & Company, Somerville (N.J.), has been announced by the firm's board of directors.

Egan, founder of the company which manufactures machinery for the paper converting and plastics industries, formerly served as president. He is succeeded in that post by Vice President Edward F. Egan of Martinsville (N.J.).

David A. Verner, also of Martinsville, was named to the newly created position of chief engineer, following Edward Egan's promotion to the presidency.

William E. Sauey

William E. Sauey, president of Flambeau Plastics Corporation, Baraboo, Wisconsin, has just announced the appointment of Joseph E. Phalon as sales manager of the proprietory division of the firm. This division includes housewares, premiums, and advertising specialties.

John A. Alesi

Mr. John A. Alesi, president of the Automatic Molding Machine Company, manufacturer of "Automold" fully automatic 25 and 50 ton compression molding machines, and the versatile "Automite" 10 ton press just recently announced to the trade, announces the appointment of Barnett J. Danson & Associates Limited, 1912 Avenue Road, Toronto 12, Ontario, Canada, telephone Russell 1-5701, to handle "Automold" sales in the Dominion of Canada.

T. R. Callahan

The Watson-Stillman Press Division, Farrel-Birmingham Company, Inc., Roselle, New Jersey, has announced the appointment of Mr. T. R. Callahan as their mid-western sales representative.

Prior to his recent appointment, Mr. Callahan represented the Company in the Buffalo-Rochester area. Mr. Callahan will make his headquarters at the Farrel-Birmingham Chicago office, 10725 South Western Avenue, Chicago 43, Illinois.

John F. Volin

Appointment of John F. Volin as Midwestern Representative for Fiberfil, Inc., Warsaw, Indiana, has been announced by John H. Keeley, Fiberfil's sales manager.

Industrial Literature

Polymers

Polymer Research. Polytechnic Institute of Brooklyn for Office of Naval Research. Feb. 1955-Jan. 1956. 55 pages. $1.50. (Order PB 121832 from OTS, U. S. Department of Commerce, Washington 25.) This annual report is concerned with experiments with polymer adsorption and investigation of the effect of polymer structure on wash primer. A section of the volume deals with problems in the fundamentals of polymer surface action, with emphasis on the physical chemistry of attachment of a polymer to a solid surface in a system where the chemical complexity of the mixture approaches an actual wash primer. The molecular weight dependence of the initial part of the adsorption isotherm is predicted. Previous studies are extended on the adsorption and desorption of polyvinyl acetate from metal surfaces. The effects of solvent and molecular weight are investigated and the nature of solution-surface equilibrium discussed. A second section continues earlier work on chromium phosphate wash primer. Existence of a polyelectrolyte in the chromium-polymer complex is reconfirmed, and some experiments on the conductivity of diluted wash primer are compared with p-toluenesulfonic acid and phosphoric acid. The final section is a further investigation of the hydrolysis of acetal linkages in polyvinyl butyral. Some linkages were found more stable than others, and this behavior is explained.

Plaskon Compounds

A 73-page illustrated handbook which details the basic principles of molding and handling Plaskon urea and melamine molding compounds is offered by Barrett Division, Allied Chemical & Dye Corp. Because of its general nature, the handbook is believed to be of value not only to molders, but to mold makers, designers and engineers.

The manual has been compiled as a general guide to the proper storage, preforming, preheating, molding, finishing and testing of Plaskon urea and melamine molding materials. Its three sections include basic information on molding; properties of the molded products; and general reference material.

Illustrations include diagrams and four-color representations of end products. Text is supplemented by charts, graphs and mathematical and physical conversion tables.

Chemical Resistance

Chemical Resistance of Plastics. Bureau of Ships, U. S. Navy. Mar. 1954. 475 pages. $9. (Order PB 121133 from OTS, U. S. Department of Commerce, Washington 25.) In a literature survey conducted prior to this research, it was found that information on the chemical resistance of plastics was widely scattered and generally qualitative, rather than quantitative and specific. As a result, laboratory tests were conducted on the effects of chemical agents on plastics. This volume brings together the large amount of data gained from the experimentation. The 25 plastic materials tested were composed of thermoplastic and thermosetting resins, and are said to represent a reasonably broad cross-section of commercially available rigid plastics. The group of 15 chemical agents contained common mineral acids in dilute, concentrated and fuming concentrations, acid mixtures of fuming concentrations, a mercaptan, an alcohol, two fuel oils, a hydraulic fluid, a peroxide, gasoline, water, and an analine. From the data it is possible to deduce the behavior of any given plastic on immersion in a given agent, and the change in certain key physical properties as a result of prolonged contact.

Polyester Resins

Of interest to fabricators and molders of reinforced plastics are three new brochures on polyester resins recently issued by Rohm & Haas Company. One booklet of 36 pages (code number PL-316) deals with the properties of the company's Paraplex P-series, including the new acrylic-modified resin which is attracting widespread attention in the plastics industry, Paraplex P-444. Reinforcement and fabrication are the subjects covered in the 16 pages of the second brochure of the trio (PL-322), and curing is the theme of the third booklet of 24 pages (PL-323). The text of all three is helpfully supplemented by numerous data tables and performance graphs. These tables and graphs make up practical working charts to guide users of the resins in each step of processing. The booklets, singly or as a set, are available upon request to Rohm & Haas Company, Plastics Department, Washington Square, Philadelphia 5, Pennsylvania.

Loaded Dielectric Foams

Loaded Dielectric Foams. G. E. Niles, Emerson and Cuming, Inc. for Wright Air Development Center, U.S. Air Force. Dec. 1956. 51 pages. $1.50. (Order PB 121897 from OTS, U. S. Department of Commerce, Washington 25.) The development reported in this paper filled a need for a lightweight material of high dielectric constant for use in sandwich radome construction. The material was based on foaming resin systems loaded with aluminum microflake to achieve the necessary dielectric constant and at the same time retain much of the low bulk density of the foamed resin. Isocyanate resinous foams loaded with aluminum microflake were successfully made. They compared favorably electrically with other radome core materials. Processes for loaded dielectric foams were developed which allow good process control resulting in a material of predictable properties. Development of a method of construction and submission of a radome demonstrated the practical application of loaded dielectric foams as the core in sandwich-type half-wavelength radomes. Flaked aluminum applied as a paste was found better than silver and nickel for loading foams and increasing the dielectric constant.

Printed Circuits

A new booklet entitled "Westinghouse Copper-Clad Micarta Plastic Laminate For Printed Circuits" is available from Westinghouse Electric Corporation. The booklet, illustrated with photographs and diagrams, discusses what printed circuits are, the advantages to be gained from their use, and the construction and properties of Micarta plastic laminate. A complete data sheet for all the copper-clad Micarta plastic laminate types is included.

For a copy of booklet B-6577, write Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh 30, Pa.

Stearic Acids

"Emersol Stearic Acids" is the title of a new, 24-page booklet being offered by Emery Industries, Inc.

Available upon request, the brochure is designed to aid in the selection of the proper grade of stearic acid for each end use.

"Emersol Stearic Acids" can be obtained by writing: Emery Industries, Inc., Dept. 5, Carew Tower, Cincinnati 2, Ohio.

Injection Machine

The Hydraulic Press Mfg. Co., A Division of Koehring Company, Mount Gilead, Ohio offers a new bulletin, No. 5706, which describes a new H-P-M 6/8 ounce capacity plastics injection molding machine. Several views of the H-P-M Model 200-H-6/8 point out important new features. Complete specifications, standard and optional equipment, are covered.

Paint and PVC Resins

Two informative, interesting technical bulletins prepared expressly for paint manufacturers and polyvinyl chloride resin compounders respectively have just been issued by the Silicate, Detergent, Calcium Division of Diamond Alkali Company, Cleveland, Ohio.

The first, entitled "Low Sheen Flat Alkayd Wall Paints with Non-Fer-Al," conveniently summarizes the principal advantages provided by this Diamond precipitated calcium carbonate when used as an extender in formulating "dead flat" type wall paints.

"Diamond Precipitated Calcium Carbonates for Polyvinyl Chloride Applications," a 16-page bulletin, briefly reviews the use of eight Diamond chemicals as inert fillers for compounding polyvinyl chloride plastic products.

Copies of these fact-filled technical bulletins are available on request. Write to Diamond Alkali Company, Silicate, Detergent, Calcium Division, 300 Union Commerce Building, Cleveland 14, Ohio.

Extruder Design

"How To Choose An Extruder" is an impartial engineering analysis of current plastics extruder design, and contains a great wealth of information on the principles of extrusion in their latest form.

The publishers will be glad to send complimentary copies of this 52 page booklet to any who may be interested. Write to Prodex Corp., King George Post Road, Fords, N.J.

Thiokol Polymer

Thiokol Chemical Corporation has issued an eight-page booklet concerning the new Thiokol liquid polymer LP-31, which has the highest molecular weight of the liquid polysulfide polymers manufactured by Thiokol Chemical Corporation.

This literature is available upon request from Thiokol Chemical Corporation. Thiokol Chemical Corporation, 780 North Clinton Avenue, Trenton 7, New Jersey.

Plastic Pipe Process

A new process for extremely rapid and continuous production of plastic pipe, using a combination of physical and chemical processes, is announced by S. Orlowski, Matieres Plastiques, 13, Impasse Jouvence, Paris XIV, France. Literature available on request.

Japanese Plastics

Statistics of Plastics Industry in Japan is available from R. Sekido, Tomio-cho, Nara, Japan for 400 yen. This 34 page booklet gives data on production and foreign trade. It is written in English.

Plastic Coatings

"Fluidized Plastic Coatings For Corrosion Resistance" is the title of a special report, available in literature form, from the American Agile Corporation, Maple Heights (Cleveland), Ohio.

The six-page literature, a reprint of a feature article, covers such topics as the mechanism of fluidization, coatings available, cost factors, and applications.

Hercules Magazine

A new company magazine Plastics Hi-Lites is being put out by Hercules Powder Co., Wilmington, Delaware to keep the reader up to date on the Hercules plastics. Write for your copies to Hercules.

Injection Machine

The Hydraulic Press Mfg. Co., A Division of Koehring Company, Mount Gilead, Ohio offers a new bulletin, No. 5720, which describes a new H-P-M 20/28 ounce capacity plastics injection molding machine. Several views of the H-P-M Model 450-HV-20/28 point out important new features. Complete specifications, standard and optional equipment, are covered.

Color Variations

We have available a four page technical service bulletin covering Color Variations, Their Causes and Corrections in coatings for plastics. This booklet describes pigments, the various types used in coatings for plastics, color matching, and techniques used to check colors. Logo, Inc., 12933 South Stony Island Ave., Chicago 33, Ill.

Polyamide Synthesis

An Approach to the Synthesis of a polyamide plastic with hydrophilic properties, E. L. Totton, North Carolina College at Durham for Wright Air Development Center. June 1956. 16 pages. 50 cents. (Order PB 121473 from OTS, U. S. Department of Commerce, Washington 25.) This volume reports an apparently successful new approach to the synthesis of tetra-O-methyl-D-glucaric acid. The author utilized the lactone of D-glucaric acid for the preparation of the di-p-toluidide of D-glucaric acid, the di-p-hydroxyanilide of D-glucaric acid, the tetra-O-acetyl-di-p-toluidide of D-glucaric acid, and the hexa-O-acetyl-di-p-hydroxyanilide of D-glucaric acid. Methylation of tetra-O-acetyl-di-p-toluidide of D-glucaric acid resulted in a water-soluble syrup. This product was treated with sodium hydroxide in ethylene glycol and a salt was isolated. The salt was acidified with hydrochloric acid and a water-soluble syrup was produced which was thought to be tetra-O-methyl-D-glucaric acid. The water-solubility of the syrup indicated that it might produce a polymer with hydrophilic properties.

Radome Design

Phase Retardation Design Curves for Solid Lossless Dielectric Panels, E. J. Luoma, Wright Air Development Center, U. S. Air Force, Feb. 1956. 27 pages. 75 cents. (Order PB 121783 from OTS, U. S. Department of Commerce, Washington 25.) This report presents data on radome design in a manner which provides the designer with a clearer perspective of design parameter variations in terms of overall performance. There was a need in the variety of design curves available for solid walls for a presentation of radome design data in which the thickness-to-wavelength is plotted as a function of incidence angle with the phase retardation remaining constant. The graphs in this volume provide some of that data for the solid lossless case. A conclusion of the data processing recommends that for more complex radome walls, the explicit transcendental equation for phase retardation should be solved before obtaining the constant phase retardation data by graphical cross plotting.

Stress Data

Viscoelastic Properties of High Polymers: Table of Stress-Relaxation Data, E. Catsiff and A. V. Tobolsky, Princeton University for Office of Naval Research. June 1956. 49 pages. $1.25. (Order PB 121749 from OTS, U. S. Department of Commerce, Washington 25.) This volume contains a compilation of the results of stress-relaxation studies of numerous polymers. For ease of presentation, the tabulated data were read at uniform logarithmic time intervals from smooth curves drawn through the experimental points. In all other respects, the tables consist of raw experimental data. The tables also list certain empirical parameters which may be regarded as measures of the steepness of the experimental curves and of their location on the absolute time and modulus scales. Included in the 19 tables are data on such polymers as polyisobutylene, natural rubber, gum stock, tread stock, butadiene-styrene, paracril 26, polymethyl methacrylate, and Kel-F elastomer.

Coordination Polymers

Coordination Polymers, W. C. Fernelius, Pennsylvania State University for Wright Air Development Center, U. S. Air Force, Oct. 1956. 106 pages. $2.75. (Order PB 121867 from OTS, U. S. Department of Commerce, Washington 25.) Polymers can be prepared through coordination, according to the results of this study. The coordination concept, which is characterized by the grouping of negatively charged or neutral units around a central metal ion, has been largely ignored in the search for improved methods of producing high polymers. This research provides information on organic metal-coordination polymers with exceptional thermal stability.

AROUND THE WORLD

AUSTRALIA

PLASTICS & RUBBER JOURNAL
May, 1957
Volume 13 No. 142
Abstracter: Albert Lightbody

Polyurethane Foams and Rubbers, Their Properties, Manufacture and Uses — *J. Yuer*

A good review of polyurethane chemistry showing the basic relationships between the chemical reactions and the resulting materials, as foams and solid polymers. This is accompanied by an excellent review of its uses with cross comparisons with other materials.

★

UNITED STATES

MATERIALS IN DESIGN ENGINEERING
Volume 46 No. 1
July 1957
Abstracter: Leonard Buchoff

Cast Epoxy Insulation Makes a Better Stator — *D. E. Crawford*

This article describes briefly the reasons for changing from varnish impregnating stators to vacuum casting with epoxy resin. Techniques of manufacturing are also discussed. Epoxy's low weight loss at high temperatures and ability to withstand rapid temperature changes were considered to be the most critical properties. Hysol 6020 with slate or quartz fillers met the requirements.

Centrifrigal casting was tried and abandoned because of bubbles formed in the top of the stator casting.

The mold was built with an expandable center to provide vacuum tight seals and keep the pole faces free of resin.

The Fluoro-Elastomers: Latest Weapon Against Heat and Fluids — *Malcolm W. Riley*

Kel-F elastomer, copolymer of chlorotrifluoroethylene and vinylidene fluoride; Silastic LS-53, a fluoroalkyl silicone rubber: Fluoro-Rubber 1F4 and 2F4, perfluorobutyl acrylate rubbers; Vitron A, polymer of vinylidene fluoride and perfluoropropylene; and hexafluoropenta - methylene adipate polyesters are discussed. Data on the degradation of these materials under the influence of temperature and chemicals are given extensive charts and tables. Although no direct comparisons between the materials are made, the information is presented in a manner that should help in making a selection among these materials.

★

FRANCE

PENSER PLASTIQUES
April, 1957
Volume 64 No. 16
Abstracter: Kenneth Downing

An Exhibition of Children's Plastic Toys —

This issue is devoted to the exhibition of plastics for children. It shows the tremendous variety of inflatable toys, floating toys, sand play things, dolls, washable toys, autos and boys' playthings available to the French children.

This issue also contains an article on the advantages of fiberglass fishing rods.

Plastic Flowers and the Style of Plastic Baskets

A pictorial study of the plastic flowers now in production and a plant in this type production. Also a study of the many different types of polyethylene baskets being produced.

★

GERMANY

KUNSTSTOFFE
July, 1957
Abstracter: Anne Schwend

Plastics and Plastics Processing at the 1957 German Industry Fair at Hanover

While there is hardly any news to be reported about new plastics materials, news is held in store by the processing and machinery fields as follows:

The Gevetex Co. demonstrated the advance of glass fibre reinforced plastics by a number of progressive parts such as gear boxes and machine parts to be used at elevated temperatures, a hood for outboard engines with strong sound absorbing qualities, printed and etched circuits using glass fibre reinforced epoxyde as carrying film which does not tear any longer because the glass fibres diminish both elongation and shrinkage and ameliorate the insulating values.

Amorgana GmbH. showed the latest developments in transparent rigid PVC film of higher heat resistance than hitherto known.

Ciba A. G. introduced their newly developed Araldit molding compounds with various fillers for transfer molding as well as Melopas AR, a special molding compound for switches of high thermal stability.

Dansk Thermoplastiks Industry exhibited a three-bladed propeller for 45 ton fishing boats with Diesel engines of 150 HP. The 3 injection molded polycaprolactam blades are held by a bronze spinner. This new propeller possesses considerable damping powers against shocks which are ordinarily transfered to the engine. It is hoped that such polyamide propellers prove particularly satisfactory for trips to icy waters.

Deutsche Tafelglas A. G., is silicate glass manufacturer, have now entered the plastics field with glass fibre reinforced polyester plates with a metal frame polymerized into the plates for windows, with plates for skylights and their "Shed-Polydet" corrugated glass fibre reinforced polyester plates which, parallel to the ridges, are absorbing and reflecting light and heat rays of the sun if properly laid out on roofs towards the South.

Kalle & Co. showed a new plastic sponge of extraordinary tear and abrasion resistance which can be wrung and used on metal surfaces with cracks, burrs and sharp edges without suffering.

Injection molded polyadmide hinges for cupboards, doors, containers and beds by Kolibri-Werk found much interest.

Interesting examples for film roofings of PVC were shown by Kunststoffverarbeitungs-GmbH.

Rheinische Gummi—and Celluloid—Fabrik showed Suprastyrol plates

from "Novodur" co-polymer of styrol, acrylonitrile and butadiene for large parts of high impact strength, and "Rhenoglas" for automobile window shields.

Rohm and Haas' Plexigum 8081 is used for coating wood coverings with the viscous monomer which hardens on the spot and protects the surface against water, alkalies, scratches and even the heat from cigarettes.

Ruhr-Kunststoff GmbH. introduced a new heating pad which is non-inflammable, water-tight, acid-proof and can be washed, disinfected and does not hold any textile material any longer except for a cover to satisfy customer's wishes.

A new sound deadener for sheet metal with benzene, oil and age resisting properties was shown by Dr. A. Stankiewicz GmbH.

Wolff and Co. introduced a new sandwich film consisting of two layers of cellophane laminated with wax in normal and weather-proof execution, for packaging purposes which demand high mechanical strength, water vapor impermeability and odor-tightness.

Dr. Beck & Co. have developed "Dobeckan IF", a special non-saturated polyester resin of lower shrinkage than normal (3 to 5% only) for casting molds, highly glossy coatings and potting of parts.

Interesting news were disclosed by Duerrkopp-Werke in the form of their ball and socket joints with plastic gliding planes firmly molded into the outer body which enjoy preference in cases of oscillating movements with higher frequencies as presented by packaging, textile, printing machines and machine-tools as well as craft.

Among injection molding machines those equipped with screws drew particular attention.

Two such types of 275 and 730 grams capacity are now built by Ankerwerk Gebr. Goller. A screw resembling that of an extruder, feeds, plasticizes and injects the plastic materials through the nozzle into the mold. Molding pressure in these new machines is lower than in customary machines, the maximum molding area augments up to 40%, at the customary mold closing pressure. Superiority over customary types is claimed by a shorter stay of the plastics in the cylinder, complete homogenization of the melt and better moldability of such plastics as high-moleculars, rigid PVC and powdery materials.

Maschinenfabrik Albert Stuebbe developed a hydraulic injection molding machine with interchangeable screw plunger and normal type plunger. A novel electronic thermostat guarantees accurate automatic temperature control.

The third type of screw injection molding machine was exhibited by Eckert & Ziegler which is built in cooperation with Maschinenfabrik A. Reifenhaeuser.

New designs of conventional type injection molding machines were introduced by:

Eckert & Ziegler — a fully automatic machine for 70 grams of polystyrene with electro-hydraulic drive.

Netstal A.G. — a high-speed automatic machine for 500 grams in polystyrene with 2 or 3 interchangeable injection plungers.

Dr. Fritz Sommer—3 new types for 30, 100 and 180 grams, for fully hydraulic operation without intercalation of a mechanical toggle lever or other system thus causing a constant concentric pressure on the mold.

Albert Stuebbe — Type H 200 with tie bars reaching only to the stationary platen while the molding aggregate is completely unencumbered and may be displaced hydraulically and automatically.

Continuous development was exhibited by the extruders shown:

Alphine A.G. — an extruder with high-speed screw already discussed in Kunststoffe.

Friesecke & Hoepfner — a new design permitting hydraulical adjustment of the annular clearance between the conical screw end and the counter-cone at the extruder head.

Johannes Kleinewefers — an extruder with flat sheeting die and especially strong drive for materials hard to plasticize.

Krauss-Maffei — an entirely new design with vertical short screw and conical torpedo the latter effectively taking over gelatination, homogenization and mixing. High output and great safety of operation mark this machine which requires heating of barrel and chamber only at beginning of operation, but for the rest works adiabatically to a high degree.

A new complete tube extruder with horizontal blowing machine was shown by Maschinenfabrik Paul Troester. Expansion possibilities are judged higher in horizontal than in vertical construction, the output is higher in such an installation, too.

Maschinenfabrik Battenfeld introduced a novel blowing machine for fully automatic production of hollow bodies. The mandrel extends beyond the separator head through the upper land into the interior of the blow mold, making it possible to blow the air through the mandrel while with customary bottle molding the landed tube in the cavity had to be opened with a needle.

An automatic blow molding attachment for extruders is supplied by Maschinenfabrik P. Flesch.

Further, a great number of new and customary welding machines and tongs for sundry materials, cutting and profiling machines for expanded plastics, punches, a new automatic cycling device, heaters and coolers for injection and vacuum molds, granulator heads, calendars and a pneumatic granule feeder to be hooked to any hopper deserve mentioning.

Fatigue Life of Glass Fibre Reinforced Plastics — *Harro Hagen*

The use of glass fibre reinforced plastics as carrying constructional elements has been put into effect without exact knowledge of the fatigue properties of the material. Information on this subject is now being gathered in many countries. This article holds a compilation of test results that have become known so far on static and dynamic endurance tests.

A New Double Screw Extruder

Description of the remarkable double screw extruder by Mapre S.A., Luxembourg, incorporating a novel solution for controlling the back pressure.

Influence of Surface Layers on the Strength of Injection Molded Polystyrene Parts — *Hilding Hoegberg*

Internal stresses, different density in various sections of injection molded polystyrene test bars and insufficient orientation of molecules all contribute to the anisotropy of parts. The choice of high cylinder temperatures and short plunger-forward-times produced parts of low or no internal stresses, excellent molecular orientation and hardly any difference in density throughout the parts. Low cylinder temperatures will yield parts of higher impact strength, but higher anisotropy too. Annealing has in all cases eliminated surface stresses and augmented age resistance.

Determination of Reactivity of Xylenol Mixtures by Measuring Turbidity and Heat Change — *Martin Krahl*

Due to observations that xylenol of different origin causes different reactions in phenol, a new method was sought to reliably determine the time needed to induce turbidity and the maximum heat of reaction. Clouding of the mixtures in a test tube was measured by a stop watch and the reaction heat by a thermometer or a temperature recorder.

Determination and Importance of Polyamide Flow Properties upon Injection Molding — *W. Hechelhammer and W. Backofen*

Injection molding of polyamide into an open spiral mold and measuring the length of the spiral molded resulted in the following conclusions:

1. The molding temperature highly influences the flow properties due to the narrow plastic zone and the dependence of viscosity on the temperature.
2. The influence of the mold temperature on the flow length is low below 80°C., but considerable above 145°C.

Five other conclusions are also reported.

SECTION NEWS

Edited by David Mersey

St. Louis

Tooling For Injection Molding Scheduled For September

W. J. Sharbaugh

As we go to press, the St. Louis Section, S.P.E., opens its Fall, 1957 season September 17th at a new meeting place chosen to better serve the fast growth of this section. Following the trend to the suburbs, the officers and program committee have moved the meeting location to the Prime Rib, Clayton Road, from the previous Melbourne Hotel, midtown location.

Improved meeting room facilities, ample parking, central location, and unexcelled cuisine are expected to assist materially in maintaining meeting attendance at high levels. If you are in St. Louis "the 3rd Tuesday" be sure to join us at our new meeting house. Cocktails at 6:00 p.m.—dinner at 7:00 p.m.—meeting at 8:00 p.m.

Mr. N. C. Taylor, Service Engineer, Tenite Division, Tennessee Eastman, is flying in from Los Angeles to present a program on "Tooling for Injection Molding." We expect to submit some interesting notes on his program in next month's section report.

The S.P.E. October meeting is a joint meeting with the American Chemical Society. This special meeting will be held at the Engineers' Club, Lindell Boulevard, October 17th (3rd THURSDAY). Both groups are joining to hear Mr. Elmer Schule, Group Leader, Allied Chemical and Dye Central Research Lab, present a discussion on "Caprolactam Type Nylons." The speaker will be accompanied by Mr. Dave Caldwell, Product Supervisor, Molding Materials, Plaskon Division.

We will be in session again at the Prime Rib for the November meeting, Tuesday, the 19th, to hear Mr. Art Nufer, Senior Technical Representative, American Cyanimid Company, discuss "Methylstyrene Molding Compounds."

Remember—It's the Prime Rib, Clayton Road, 3rd Tuesday, for a pleasant evening with the St. Louis Section when you are in St. Louis.

Binghamton

First Annual Dinner Dance

L. N. Chellis

The last meeting of the season was devoted to what we plan will become an annual feature. On May 18, the first annual Dinner—Dance was held in the Starlight Room of the Hotel Carlton. Fifty-two couples turned out to enjoy an evening of cocktails, dinner and dancing. A large number of door prizes were distributed among the ladies.

Felix Aimmonetti, Leo Pranitis, Frank Reynolds, Joe Venne, Wilbur Kupfrian and Jack Gwyn comprised the Dinner—Dance Committee and deserve a big hand for the outstanding success that it was.

Speakers scheduled for succeeding months are as follows:

October: Mr. Vern Hannaford, Dow Chemical Company "New Developments in Injection Molding".

November: Mr. A. J. Guzzetti Bakelite Corporation "Shrinkage of Thermosets".

The nominating committee, under the chairmanship of Len Wheeler, American Plastics, is drawing up a slate for election of new directors in November.

Cleveland-Akron

Rigid PVC

Robert A. Larsen

The fall session of the Cleveland-Akron SPE was started by a Kick-Off in timing, with a Clam Bake, held at the Brecksville Reservation, in the Cleveland Metropolitan Park on August 26th, 1957. Nearly one hundred members and guests were in attendance and various techniques were exhibited in the consumption of the generous servings available. This is the second year for this feature and has been well attended both times.

On Sept. 9th, some 90 members and guests turned out at the Spanish Tavern, Brecksville to hear Mr. F. W. Schneider, Firestone Plastics Company, speak on "The Extrusion and Physical Properties of Rigid PVC Compounds" and Mr. T. A. Miller, President, Akron Pressform Mold Company, on "Rotational Molding of Hollow Vinyl Plastisol Parts".

During the coffee break President Ed Campi, Int'l Molded Plastics, announced the proposed establishment of a committee on, and in line with National Council, to be known as "Professional Activity Group". Special attention was called to the October 17th, Cleveland-Akron SPE "POLYETHYLENE TECHNICAL CONFERENCE". This will be held at the Carter Hotel, Cleveland, and pre-registration sent to E. J. Haskins, Zenith Plastics Co., 1009 Rockwell Ave., Cleve-14, O, is worth $1.00. Pre-registration—$9.00—At the Door $10.-00. Registration includes luncheon and preprint book. Our custodian of the treasury, Ken Keller, Keller Products Inc., reported we were in the black and that the future was rosy. Bob Hershey, Hoover Company, Program Chairman, reported on programs for the coming months thru March. All members have been provided with this schedule and more than the usual compliment should be given to Bob and his committee for this well planned program.

Mr. Schneider discussed fused and semi-fused PVC extrusion and the effect of various variables upon the physical properties of the extruded section. Screw design, temperature, pressure and compounds were some of the variables of importance.

Mr. Miller reviewed the subject of his paper from 1910 to 1957, outlining the growth and need for the same. Of interest was Mr. Miller's description of the procedure in "Rotational Molding", and present and future uses of products by this means. We need only to look at the sales of this base material to realize and agree with Mr. Miller. Samples of toys and industrial products were exhibited and a lively question session followed each speaker.

Rhode Island & S. E. Mass.

Hole-In-One At Golf Outing

Glenn A. Tanner

The annual golf outing of the Rhode Island and Southeastern Massachusetts Section was held August 29th at the Pawtucket Country Club, Pawtucket, Rhode Island. Thirty-three members checked in for golf and enjoyed this fine course in weather that could not have been more perfect. This number had swelled to fifty by the time the smorgasbord was served later in the evening.

Top honors of the day went to newly married and probably inspired Harry Mac Vicker of American Cyanamid Company. Harry managed to put together the correct combination and come up with the low net score under the handicap system. Harry was helped materially by a hole-in-one on #7. This brought him additional honors for this was the hole chosen for the "nearest-the-pin" prize. (You couldn't come closer).

President, Sydney Y. Lohman awarded the prizes for both golf and door prizes at a smorgasbord dinner.

Newark

Extrusion Symposium

Robert A. White

The following is the projected schedule of activities for the Newark Section, as announced by Mr. Vic Blatter, program committee chairman.

9 Oct. 1957

Extrusion Symposium

Panel members from the R&D Staff of Bakelite.

Moderator-Pete Wilson

13 Nov. 1957

Section Visit to Polymer Labs of W. R. Grace at Paramus, N. J.

11 Dec. 1957

Annual Section Christmas Party. Military Park Hotel.

An invitation is extended to SPE members and friends to attend these sessions at the Military Park Hotel, Newark, N. J. For additional information on the activities of the Newark Section, inquiries may be forwarded to

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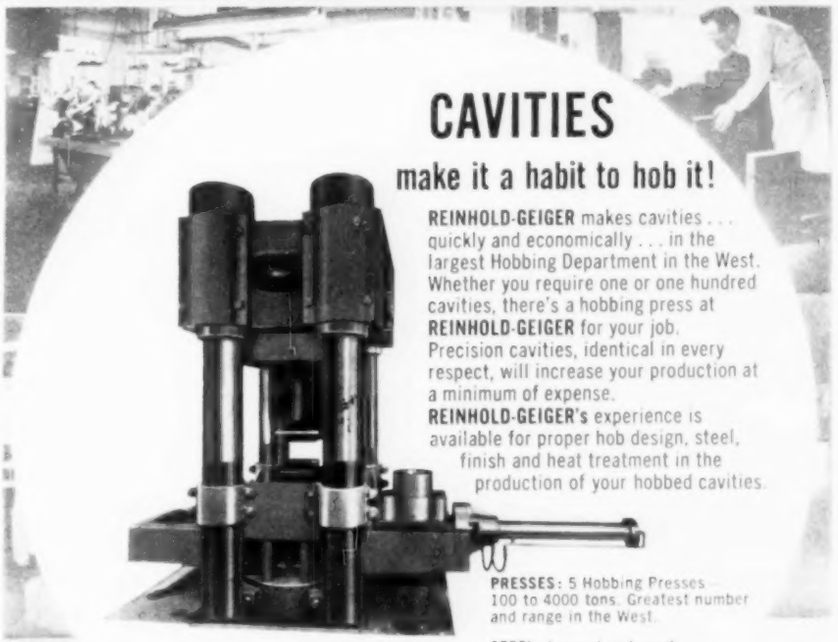

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Baltimore-Washington

Education Group Plans Active Program

Report of Education and Professional Activities Committee Chairman: Bernard G. Achhammer.

July 1957

The activities of the Education and Professional Activities Committee of the Baltimore-Washington Section are defined by three major efforts as follows: I—The Annual Technical Forum; II—Science Fairs; and III—Boy Scouts.

I—The Annual Technical Forum

This all-day technical meeting was established in 1957 as a function of the local P.A.C. The objective behind this effort is to acquaint the members of the Balto.-Wash. Section with the technical program conducted in their area through presentation of papers by **members of the Section,** and to further acquaint the members of the Section with the facilities of their area through tours of the **local plants and institutions** at which it is proposed to conduct the Annual Technical Forums.

The first all-day meeting was held in March 1957 at the Naval Ordnance Laboratory at White Oak, Maryland. The program included eight technical papers, a technical movie, and a tour of the Naval Ordnance Laboratory. It is planned to hold the 1958 Technical Forum at Baltimore.

II—Science Fairs

The educational potentialities of the Science Fairs are being investigated by the Balto.-Wash. Section through its P. A. C. financial support was provided in 1957 to the Washington Area Fairs through the Joint Board on Science Education in the Greater Washington Area. A comparable monetary gift was made to Baltimore Area Fair. Although this was the first year of a long range program, some progress was made, particularly in the Washington Area.

Judges from the B-W Section were permitted to judge all plastics entries to the four Greater Washington Area Fairs and to award prizes to the selected winners. As a result of this activity, three students and their teachers were guests of the B-W Section at the May meeting. The students brought their outstanding exhibits to the meeting and described their work at the social period preceding the dinner and talk by the technical speaker. No advance publicity of B-W's participation in the fairs was possible in 1957 because of the time factor. It is hoped that next year the number of outstanding plastics exhibits entered in the fairs will be increased. To encourage this, it is hoped that members of the B-W Section will participate in designing projects on plastics for inclusion in the booklet of suggested projects which is distributed each year to the science teachers in the area. Such projects should be a definite stimulus to interest in plastics, not only for the students but for their parents and teachers. It is also under consideration to develop summer training programs at local institutions and industry for those winners who would like to consider working or studying in the plastics field. Another facet of this program is participation in a speaker's bureau which is conducted by the Joint Board on Science Education in the Greater Washington Area. The B-W Section will provide technically competent speakers on plastics technology and polymer research.

Although the Baltimore Science Fair is not developed as highly as the Washington Area Fairs, it is hoped that by next year the B-W Section will participate in judging of plastic exhibits at Baltimore also.

III—Boy Scouts

The B-W Section P. A. C. has advised the Council Explorer Planning Committee that it would like to inform Explorer Units (and Troops with large Explorer Crews) in the Baltimore-Washington Area about the vocational Exploration opportunity in the field of plastics. The Section has agreed to send one of its members to tell Explorer units about the field of plastics if requested.

An ultimate objective of work with the Boy Scouts will be a Merit Badge in Plastics. It is presumed that local effort in this respect will need to be advanced to the national level once a firm groundwork is established.

Rocky Mountain

Fall Topic Is Cylinder Design

Mr. A. R. Morse of Injection Molders Supply Company will address the most recently formed Section of Society of Plastics Engineers, Inc., the Rocky Mountain Section in Denver, Colorado on Thursday evening, October 17th according to an announcement by Mr. O. B. Yorker, Sr., President of the new SPE Section and of Yorker & Sons, 601-03 East 48th Street, Denver, Colorado, one of the west leading molders. Mr. Morse's topic will be "Recent Developments in the Injection Industry Affecting Heating Cylinder Design".

Southern California

The Freeloader

John A. Stahmann

An automatic method for embedding metal inserts into plastic molds was described at the Southern California Section meeting on September 5th. Mr. John W. Shannon, of Whitso, Inc., was the guest speaker. Scully's Restaurant in Los Angeles was the locale. Following the discussion a movie was given which illustrated the operation of the device.

The "Freeloader" consists of an oscillating box or boxes, rotating around a hollow shaft. One face of each box is a replaceable plate in the same pattern as the cavities which will need inserts. Quantities of inserts are loaded into each box and are rocked back and forth at 15-20 times per minute. The inserts move into the holes of the collector plate of the box assisted by air pressure.

Removing the collector plate when loaded, the operator transfers the inserts directly into the mold cavities or by means of an intermediate pick-up device (when they must be reversed).

For use with the "Freeloader", some inserts must be redesigned in size or shape, although washers, beads, terminals, screws, and long pins have all been used.

While the apparatus is fairly simple in construction, an outstanding advantage is the speed of loading. Dual or triple sets of collector sets may be employed.

Chicago

Mold Making

Joseph J. Schmidt

Chicago Section members and guests turned out 167 strong for the first 1957 fall season monthly technical program held Monday evening, September 9th, in the headquarters, Western Society of Engineers.

Harold Sexauer, engineering representative of the Elox Corporation of Michigan spoke on the subject of the Elox Process of mold making by metal disintegration methods. Sexauer's presentation included a one-half hour color and sound movie which further demonstrated this electronic method of processing mold cavities and die inserts.

A lively question and answer session concluded the very enlightening technical session.

Airborne Electronics
See Page 65

Plastics Costs Are A Challenge

New Officers Are Announced

Judd Holt

Hiram McCann, editor of Modern Plastics Magazine and Modern Plastics Encyclopedia, was featured speaker at the September 11 dinner meeting which kicked off the 1957-58 season. His topic was "Challenge to Plastics."

Addressing about 90 members and guests, McCann said that the plastics industry's biggest challenge is to overcome the problems of increasing costs in an era of increasing competition. He predicted that any increase in plastics production this year (over 1956) will be "very slight" and that polyethylene will be primarily responsible for that increase. Mr. McCann's talk will appear in full in a coming issue of the SPE Journal.

Peter W. Simmons, national president, and Robert K. Gossett, national secretary, were special guests at the meeting. Each spoke briefly and congratulated the section on its "fine record."

National director George W. Martin (Holyoke Plastics Corp.) acted as introductory chairman and presented the new officers, directors and committee chairmen.

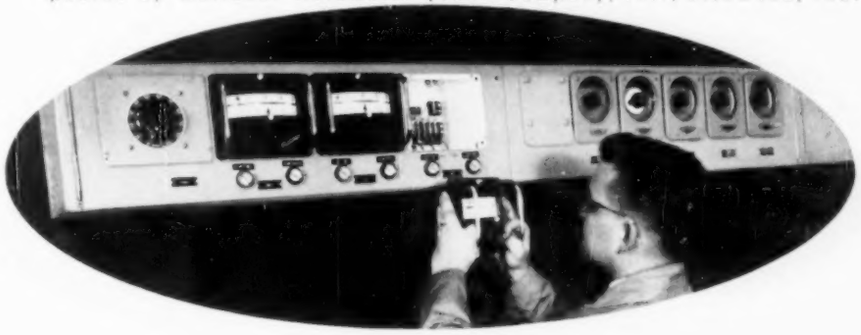
Newly elected section officers for the 1957-58 season are: president, Raymond A. Mazur (American Cyanamid); vice president, Richard J. Plichta (Fuller Brush Co.); secretary, Wesley L. Larson (DeBell and Richardson); and treasurer, Edward F. Duda (Holyoke Plastics Corp.).

New directors are: Walter E. Klesper (Holyoke Wire & Cable Corp.); Blakely McNeill (Fuller Brush Co.); and Armand Vallieres (Pro-Phy-Lac-Tic Brush Co.).

New committee chairmen are: membership, Lawrence W. Freeman (Plax Corp.); credentials, Vallieres; nominating, Klesper; election inspectors, Arthur W. Logozzo (Nutmeg Chrome Corp.); finance, Lewis H. Gustafson (Pro-Phy-Lac-Tic Brush Co.); auditing, Plichta; program, McNeill; house, Samuel E. Blumenthal (Phillips Bros. Chemical Co.); publicity & S.P.E. Journal reporter, Judd Holt (Monsanto); education, Dr. Frederic J. Locke (Monsanto); and professional activities, Thomas A. DeMarco (Monsanto).

For the first time the section met at Betty's Towne House, Agawam, Mass. Regular monthly dinner meetings for the remainder of the season are scheduled for the same restaurant.

photos by National Automatic Tool Company, Inc., Richmond, Ind.



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book reviews

Engineering Properties and Applications of Plastics

Gilbert Ford Kinney. John Wiley and Sons, 261 pp. plus tables, $6.75.

Mr. Kinney is Professor of Chemical Engineering at the U.S. Naval Postgraduate School in Monterey, California. He has attempted, with a good measure of success, to cover the broad field of plastics engineering within the tight limitations of a couple of hundred pages of printed description.

The book would be a difficult one from which to learn any particular phase of plastics engineering, primarily because of the condensation required to gather all of the information between its covers. It is encyclopedic in scope and is, rather, a good reference volume for practicing professionals. Professor Kinney uses, as the flyleaf states, "a unified treatment, rather than a topical approach, (which) permits the principles, concepts, and terminology to be established in the simpler cases, and utilized in treatment of the more complex materials."

Mechanical, electrical, optical, thermal, and chemical properties of each family of plastics are covered.

Except for a few minor errors in statistics and a bit of careless proofreading (which, in most cases, is obvious), the book is well done and would be a useful addition to the reference shelf of any plastics engineer.

Samuel S. Oleesky

Transactions of the Society of Rheology

Interscience Publishers, Inc., 250 Fifth Ave., New York, N. Y. 222 pages. $6.00.

The first volume of the Transactions of the Society of Rheology provides a convenient summary of the 1956 meeting of the Society. Several of the papers are of direct interest to plastics engineers. One of these describes a motion picture, which was shown at the 1957 SPE meeting, on flow of polyethylene in glass capillaries at high stresses. Other papers treat the generation of heat during flow at high stress and measurement of viscosity of plastisols at elevated temperature.

The normal stress effect (development of stress at right angles to the applied shear stress) for polymer solutions is described in four papers, two theoretical and two practical. Two other papers treat the viscosity of suspensions of spheres and dumbells. In a theoretical paper, viscous flow is considered in terms of an elastic continuum with a stress relaxation mechanism.

Various aspects of the properties of solids are the subjects of other papers: hydrogen embrittlement of titantium alloys, fracture in fibers, and behavior of an ideal strain hardening solid.

The Society's Committee on Nomenclature presented their proposed nomenclature for linear viscoelastic behavior.

John P. Tordella

Clinical Toxicology of Commercial Products

Marion Gleason, Robert Gosselin and Harold C. Hodge. The Williams & Wilkins Co., Baltimore, Md., 1957, 1160 pp. $16.00

This manual is divided into seven sections which are color coded, thus enabling speedy consultation. The first four sections describe first aid, toxicity of common ingredients, elementary therapeutics and supportive treatment. Section V, the largest one, contains over 800 pages and gives an alphabetical listing of over 15,000 trade name products and for each one the category of use, the major toxic ingredients and their manufacturer. Sections VI and VII give the basic formulae for types of products and the names and addresses of manufacturers whose products are mentioned in the previous sections.

This book obviously represents a tremendous amount of compilation work and as such will render a great service to users of chemicals in the factory, in the home and on the farm. Thousands of workers die every year from their ignorance of the toxicity of the chemicals they handle every day. Reading this book will prevent a great many accidents.

However, we are anxiously awaiting the publication of the supplement, (whose price is included in the original price of the book), because there are many, in fact much too many omissions. Several solvents used in the plastics and allied industries are missing. So are raw materials used in the cosmetic industry despite their relatively high toxicity. A great many trade names of well known harmless cosmetics are mentioned whereas dangerous ones such as hair dyes, waving lotions, eye lotions, detergents and many others are conspicuously forgotten. Finally, a great many trade names are mentioned without their formulae, and such rudimentary nomenclature is of no value whatsoever.

Let's hope that the supplement will correct most of these mistakes and omissions. Unfortunately, we believe that in order to achieve this, it should be almost as big as the book itself.

Louis C. Barail

Unit Operations of Chemical Engineering

Warren L. McCabe and Julian C. Smith. McGraw Hill Book Co., Inc., New York, 1956, 947pp, $10.50

This book covers the unit operations of chemical engineering from both a practical and theoretical standpoint. A few conventional operations have been omitted in order to give more space to more important topics. Such are fluid mechanics, transportation of fluids, handling of solids, mixing, mechanical separations, heat, evaporation, gas absorption, distillation, cristallization, drying and many others. This book is well written and very easy to read, contains 113 worked out examples, 150 unsolved problems, 500 figures and 275 bibliographical references.

Although it is written mostly for college students, the information it contains will help many plastics engineers since many of their problems dealing with unit operations in chemical engineering and applied physics are herein described and solved for them.

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STERLING, INC.

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Management Views . . .

(Continued from Page 54)

Chrysler at 15.9. This year G.M.'s percentage slid to 45.3, while Ford rose to 30.1 and Chrysler to 19. It is evident that design is going to be increasingly on the industry's mind. The all-out battle for the future lead in the automobile industry will undoubtedly be fought in great part in the styling departments. And, in the auto industry, design is an opening shot rather than a last ditch stand. This is a tactic of which the industrial designer approves because it offers him the opportunity of being of the greatest possible service.

The role of design was emphasized just recently when designer Virgil Exner of Chrysler was rewarded by promotion to vice president — matching positions held by Harley J. Earl of G.M. and George Walker of Ford.

In a field such as plastic products manufacturing, employment of extra-industry design offers a very real additional value. Approaching design from different avenues of research lends a very real additional value. It provides a broader perspective to product development. The designer works from a number of valid design premises which can serve to supplement those of the specialist. Though the industrial designer is a specialist in building up sales by appearance design, he is a general practitioner of design among industries.

From the very beginning of the rise of the plastics industry the close alliance of the designer with the field has had an important result for the designer. He has gained added competence in performing his job from the unlimited technical sources made available to him by the plastics industry itself for his problem-solving and to supplement his work of design development.

The industrial designer and the plastics engineer both suffer from the increasing complexities and explosive growth of their relatively new professions. The expansion of the plastics engineer's job is self-evident to anyone who tries to assay the plastics field. Likewise the industrial designer is facing more responsibility in continually broadening fields of marketing and research. Turning to the plastics engineer as a specialist is a necessary recourse for the designer.

Our industrial design office derives a great stimulus from the representative of the raw materials supplier and the occasional preview of a new plastic material. It may be that this is an area that can be systematically developed for mutual benefit. It is an opportunity for preliminary market sampling for the materials supplier; it is a source of significant natural design research for the industrial designer.

If the fields of industrial design and plastics engineering have a purposeful meeting, the plastic and its perfect use are more quickly brought together, with favorable results for both.

The industrial designer works for the same result as does the plastics engineer — the best use of the material to enhance the product. The outcome is to provide further use for the plastic, and increase sales for the product. The economy of the nation and the marketplaces of the world are geared to the acceptance of products made of new materials and of good design. ★★

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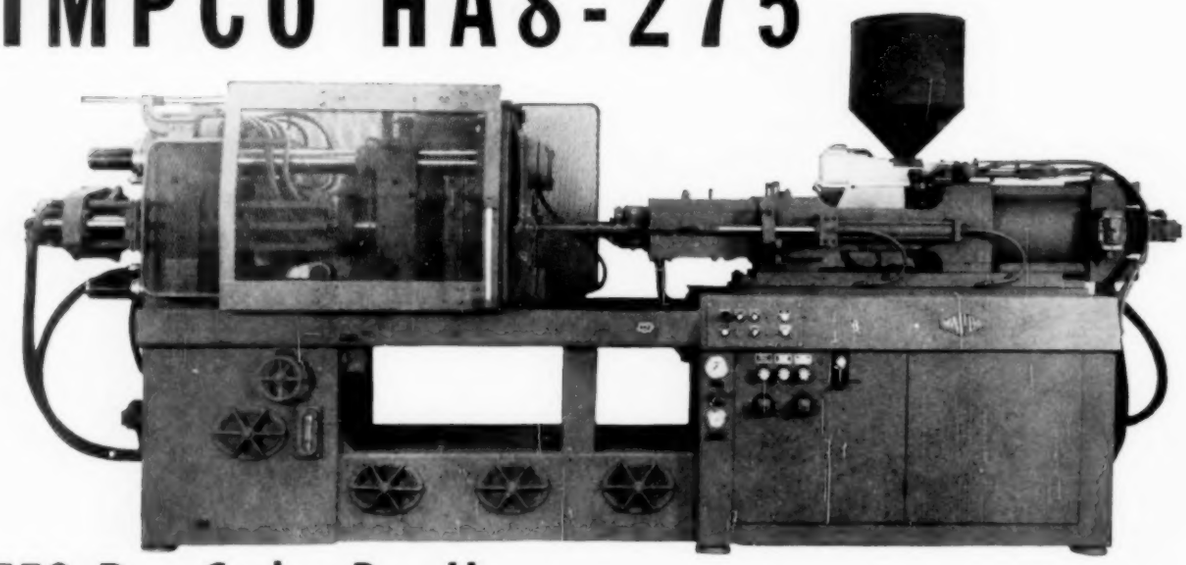

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Sandwich Construction

(Continued from Page 29)

The Westinghouse Corporation is presently marketing the horizontal built-in type unit shown in the title figure. This box is fabricated from a panel of 3" polystyrene foam core with reinforced polyester exterior facing and high impact polystyrene sheet interior facing.

The rapidly growing frozen food market necessitates the use of moveable insulated partitions so the freezer requirements can be revised readily. Panels and cold storage doors made of expanded polystyrene core and polyester-glass facings backed with plywood have many advantages in this field. For example, a door weighs less than 40 pounds compared to a conventional door well over 100 pounds.

In refrigerated warehouses polystyrene foam in two layer constructions has been sandwiched between thin layers of Portland cement mortar to serve as insulation and structural roof deck or side wall. In a Minnesota warehouse roof construction the first layer of 3" foam was mechanically fastened to the bar joists 3' on center, 1/4" Portland cement applied to it, the second 3" foam board laid and 3/8" Portland cement mortar applied over the top surface completing the sandwich. The metal deck or masonry side wall was eliminated in this construction with considerable savings in cost.

In military use the Navy is building boats and craft of unique sandwich construction. (Figure 6) Facings of glass reinforced epoxy and polyester resins are used with cores of expanded polystyrene, cellular cellulose acetate and phenolic impregnated paper honeycomb. The facings are cast on these cores with the aid of a full size mold. This boat has a very shallow draft when afloat and will not sink when completely filled with water. There are smaller boats of this construction on the market with more to come.

The range of applications discussed here utilizing panel construction of primarily one core material gives some indication of the tremendous potential in the area of sandwich construction. Because of this wide application range it is obvious that no manufacturer will come up with the universal panel; nor will any material supplier develop the ideal core, facing or adhesive material. There must always be a compromise on properties, processing techniques and cost. The sandwich panel field is just beginning to grow; the opportunity for the most versatile of materials, plastics, is almost unlimited. ★★

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Excellent opportunity for man about 26-30 with engineering degree (preferably chemical) or equivalent. Must have supervision experience preferably in quality control, and must have sound knowledge of basic fundamentals of statistical quality control. Here is an opportunity for a future with a young, aggressive and rapidly growing concern. Plant located in Finger Lakes region of western New York. Please submit complete resume to personnel department. All inquiries will be held in strict confidence. Kordite Co., Div. of Textron, Inc., Macedon, New York.

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Send complete resume including experience, education, personal history, and salary requirements to Box No. 2557, SPE JOURNAL, 34 East Putnam Avenue, Greenwich, Connecticut.

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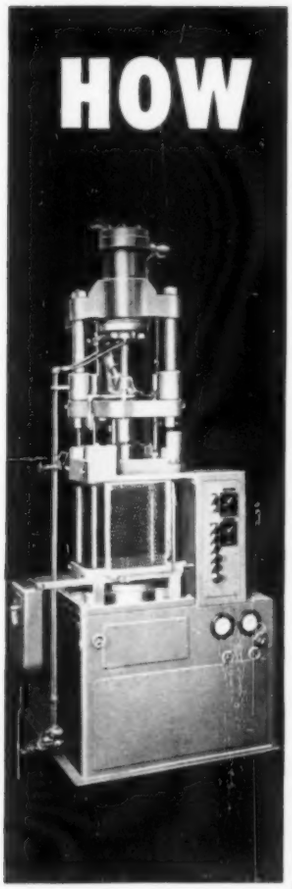

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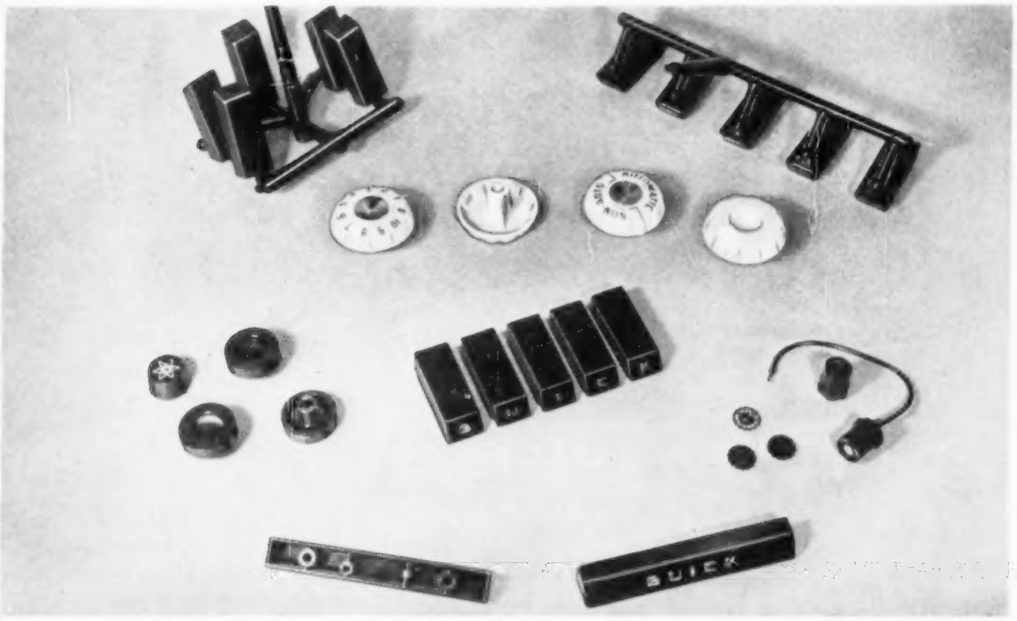

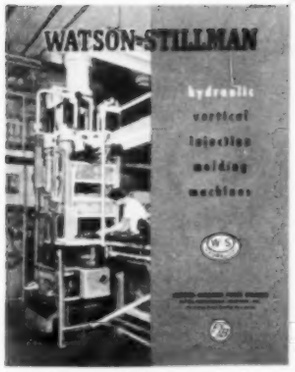

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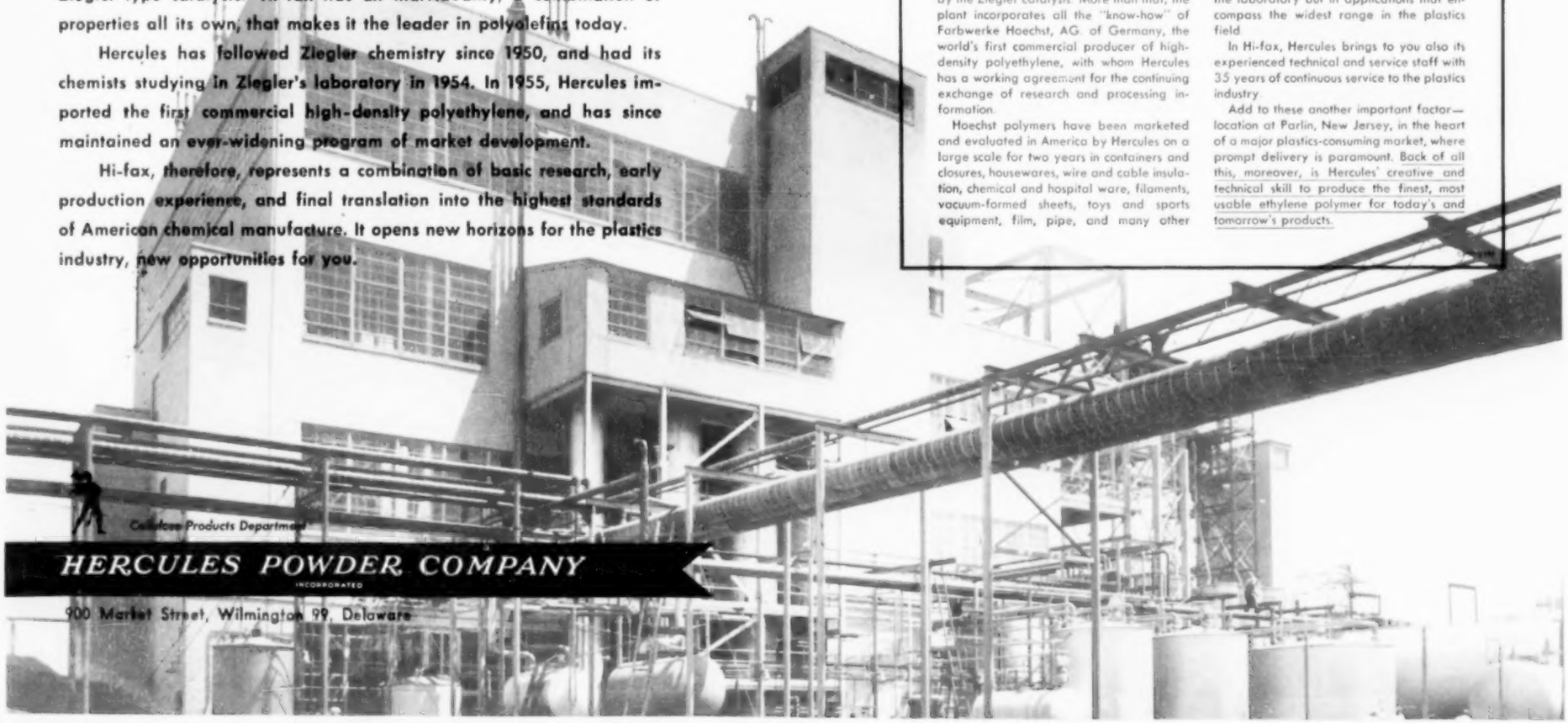

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